Regional Input-Output Modeling System

Estimation, Evaluation, and Application of a Disaggregated Regional Impact Model

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U.S. DEPARTMENT OF COMMERCE
Bureau of Economic Analysis
Regional Economic Analysis Division

BUREAU OF ECONOMIC ANALYSIS

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DEPARTMENT OF COMMERCE · UNITED STATES OF AMERICA ·

April 1981

U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary
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BUREAU OF ECONOMIC ANALYSIS
George Jaszi, Director

Foreword

In response to a growing need for improved techniques for regional impact analysis, the Regional Economic Analysis Division of the Bureau of Economic Analysis developed the Regional Industrial Multiplier System (RIMS) in the mid-1970's. RIMS was designed to estimate input-output-type multipliers for use in estimating the secondary regional impacts of public and private economic development policies. RIMS was capable of estimating multipliers for any region composed of one or more contiguous counties and for any of the 478 industrial sectors in the national input-output (I-O) model. RIMS was a significant improvement over the more summary measures often used in regional impact analysis, and was capable of providing reliable multiplier estimates, without the costly expense of gathering survey data.

The regional impact system described in this monograph--the Regional Input-Output Modeling System (RIMS II)--is a refinement of RIMS. The basic differences between RIMS II and RIMS are the use of a more recent national I-O table, the use of more detailed data for regionalizing the national I-O table, and greater flexibility in the derivation of regional impact estimates through the ability to apply either of two approaches--a shortcut method that provides aggregate impacts or a matrix inversion technique that provides industrially disaggregated impacts.

This monograph documents the structure and performance of RIMS II and provides an example of its application in analyzing regional impacts of Federal programs and policies. The monograph assumes a knowledge of I-O techniques and focuses on the technical aspects of regional I-O modeling.

April 1981

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Among those outside of BEA, we thank especially the directors of the reseach teams in Texas, Washington, and West Virginia, who estimated the survey-based regional input-output tables used in the development of RIMS II. In addition, this monograph profited from comments on papers in which we described several aspects of RIMS II; we acknowledge the comments of Robert Bolton of Williams College, Philip Bourque of the University of Washington, Mark Henry of Clemson University, Geoffrey Hewings of the University of Illinois, R.C. Jenson of the University of Queensland (Australia), Joseph Katz of the University of Arizona, William Latham of the University of Delaware, James London of the College of Charleston, Karen Polenske of the Massachusetts Institute of Technology, Dennis Robinson of the U.S. Environmental Protection Agency, Benjamin Stevens of the Regional Science Research Institute, and Anthony Yezer of George Washington University. Also, our research profited from the comments on the original RIMS model made by Andrew Issermann of the University of Illinois, William Miernyk of the University of West Virginia, and William Schaffer of the Georgia Institute of Technology.

Numerous users of the original RIMS model have provided support and comments that have enabled us to develop RIMS II. We acknowledge the support of the U.S. Water Resources Council, which, in publishing RIMS multipliers, has stimulated the use of input-output-type multipliers in regional impact analysis. For their comments and support, we wish to thank Peter Ashton of the U.S. Department of Agriculture, Louis Bykoski of the U.S. Nuclear Regulatory Commission, Hugh Knox of the U.S. Department of Commerce, John Lynch of the U.S. Department of Defense, John Ross of the U.S. Department of Housing and Urban Development, David Sandoval of the U.S. Department of Energy, Ajay Sanghi of the New York State Energy Office, and John Stutz and Steven Buchsbaum of the Energy Systems Research Group.

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Chapter 1

INTRODUCTION

Many types of public-sector and private-sector decisions require an evaluation of probable regional effects. For example, Federal requirements for environmental impact statements and urban impact analyses of Federal policies have substantially increased the need for regional impact analyses. Among the numerous aspects of a methodologically sound analysis is the consideration of indirect as well as direct impacts. Since important impacts are often economic ones, this increased concern has created a derived demand for regional economic impact models.

As a result of this demand, economic impact models have been developed for many States and regions using a variety of methodologies. The three most common types of impact models are economic base, econometric, and input-output (I-O). These models vary considerably in terms of structure, reliability, sectoral and geographic detail, flexibility in application, and cost of development and use. The most important attributes of models used for the purpose of analyzing the regional impacts of Federal policy changes include reliability as well as sectoral and geographic detail. Specifically, it is important that the impact model can be consistently applied to a variety of regions to enable comparisons of impacts of Federal policies across these areas. Unfortunately, most impact models have been developed for individual areas, making this comparison difficult.

The Regional Industrial Multiplier System (RIMS) was developed by the Bureau of Economic Analysis (BEA) in the mid-1970's to meet this analytical need. It was capable of producing I-O type industry-specific multipliers for use in impact analysis. Since its initial formulation, three changes have altered the environment within which RIMS was first developed. First, the national I-O table for 1972 is now available upon which to base multiplier estimates. Second, more detailed data describing regional industrial structure are now available. Finally, significant advancements in the state of the art in regional I-O modeling have taken place against which the original RIMS estimating methodology needs to be evaluated.

The purpose of the research described in this monograph was to develop a new version of RIMS that reflected these changes. This monograph focuses on the estimation, evaluation, and application of this new system--the Regional Input-Output Modeling System (RIMS II). Its primary use is to provide estimates of the impact of changes in the public sector (e.g., Federal policy) or in the private sector (e.g., private investment) on the economies of any county or group of counties in the United States and for any of the industrial sectors in the BEA national I-O table.

Overview of the RIMS II Approaches

As with most I-O techniques that rely on other than survey information, RIMS II estimates of regional industrial relationships are based on an existing national I-O table. For this purpose RIMS II employs the 1972 BEA national I-O table, which shows the input and output structure of 496 U.S. industries. Since firms in all national industries are not found in each region, all direct requirements in a particular region typically cannot be supplied by that region's industries. Therefore, input requirements that are produced in a study region are identified, using BEA 4-digit Standard Industrial Classification (SIC) county wage and salary data. These data function as proxies for the industry-specific input and output data, which are seldom available at the small-area level. The resulting regional I-O table then can be aggregated, using these same wage and salary data, to the level of industrial detail appropriate for the impact study.

More specifically, the RIMS II approach can be viewed as a three-step process. In the first step, the national direct-requirements-coefficients matrix is made region-specific by using corresponding 4-digit SIC location quotients (LQ's).1/ For this purpose, RIMS II employs LQ's based on two types of data. According to this mixed-LQ approach, BEA county personal income data, by place of residence, are used for the calculation of LQ's in the service sectors, while BEA earnings data, by place of work, are used for the LQ's in the nonservice sectors. The LQ's are used to estimate the extent to which direct requirements are supplied by firms within the region.

The second step involves estimations of the household row and the consumption column of the matrix. The direct household-earnings coefficients are estimated based on value-added gross-output ratios from the national table and introduced into each industry's coefficient column. In addition, a personal consumption expenditure column is constructed, based on national consumption and savings rate data and national and regional tax rate data.

The last step in the RIMS II estimating procedure is to calculate the multipliers. RIMS II employs two alternative approaches for obtaining these multipliers. For some applications, it is necessary to trace the impact of changes in final demand on numerous individual directly and indirectly affected industries. RIMS II employs the Leontief inversion approach for obtaining multipliers in these cases. This inversion process produces both gross output and earnings multipliers.

For other applications that require the calculation of only the gross output and earnings impact associated with a change in final demand for a specific industry, RIMS II employs a shortcut alpha-regression approach. According to this shortcut approach, the direct component of the multiplier is estimated as the sum of the coefficient column, including the household coefficient. Then, the indirect-induced component is derived, using a regression relationship involving the direct component in the reference industry, the average direct component for all industries, and the sum of the coefficients in the personal-consumption-expenditure column. From this estimate of the total multiplier, a shortcut formula is used to calculate the corresponding earnings multiplier.

The blending of these two approaches (alpha regression and inversion) into RIMS II greatly enhances the flexibility of the system in terms of the range of applications for which it might be employed. Furthermore, based on comparative evaluations of the errors associated with these two techniques vis-a-vis their survey-based counterparts, such flexibility is gained with no apparent loss of accuracy.

In addition to this flexibility of application, there are several other advantages to the RIMS II approaches. First, since RIMS II produces multipliers that are derived from secondary data sources, it is possible to provide estimates of economic impact without building a complete survey I-O model for each region under study. Second, the RIMS II multipliers are derived from a very limited number of secondary data sources, thus eliminating the costs associated with the compilation of data from a wide variety of these sources. Third, because of the relatively disaggregated sectoring plan employed by RIMS II, analysis may be performed at a detailed industrial level, thereby avoiding aggregation errors that often occur when different industries are combined. Fourth, the RIMS II multipliers are based on a consistent set of procedures and conventions across areas, thus making comparisons among areas more meaningful than would be the case if the results were obtained from incompatible impact models designed only for individual areas.

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1. LQ's are measures of a regional industry's share of total regional economic activity relative to that national industry's share of national economic activity; LQ's are discussed in detail in chapter 3.

Scope of the Study

This monograph is divided into seven chapters. Chapter 2 presents an overview of regional modeling approaches that have historically been used in impact analysis. Specific attention is paid to the categorization of alternative nonsurvey I-O approaches, since RIMS II is an outgrowth of these approaches.

Chapters 3 and 4 detail the methods that have been employed for estimating the direct and the indirect-induced components of I-O multipliers. Specifically, chapter 3 focuses on the manipulation of the national table and the approaches used for estimating the regional direct-requirements-coefficients matrix. Chapter 4 describes the techniques used for estimating the full multiplier matrix, as well as several shortcut techniques for estimating multipliers.

Chapter 5 contains a description of the RIMS II approaches and a statistical evaluation of their accuracy vis-a-vis several other nonsurvey techniques and survey-based I-O tables for the States of Texas, Washington, and West Virginia.

Chapter 6 demonstrates the application of RIMS II in the analysis of public policy impacts. Here, the system is employed to estimate the impacts of Local Public Works (LPW) expenditures in three SMSA's--Denver, Colorado; Detroit, Michigan; and Wilmington, North Carolina.

Chapter 7 presents the conclusions of the study in terms of the strengths and weaknesses of RIMS II. The chapter also includes a description of possible extensions to the system.

Tables defining the sectors included in each of the survey-based tables are contained in appendix A. The detailed accuracy comparisons of the alternative nonsurvey techniques appear in the tables in appendix B. The sector definitions and multipliers associated with the LPW application are included in appendix C.

Chapter 2

A REVIEW OF REGIONAL MODELING APPROACHES

Overview of Modeling Approaches

One of the earliest types of economic models used in applied regional impact analysis is the economic base model.1/ This model relates changes in indirectly affected local-service sectors to changes originating in basic (export) sectors. Because the economic base model is simple to understand and inexpensive to construct, these models have been widely used. However, a major weakness of the economic base model is that it divides local economic activity into only two broad sectors--the local-service sector and the export sector. This weakness gives rise to two significant problems in applying these models. First, the economic base multiplier is an average for the entire basic sector, and may not be the appropriate multiplier for output changes in an industry that is part of the basic sector. Second, the estimated impact is for the entire local-service sector. Therefore, the effects on specific local-service industries are not measured, even though estimating these industry-specific effects is often a major goal of impact analysis.

The two problems can be overcome by the use of I-O models, which enable the analyst to examine the interindustry multiplier differentials in detail.2/ The consideration of these multiplier differentials is particularly important, since Cartwright (1979) and others have shown that total gross-output multipliers can vary substantially among export-oriented industries, and that the industrial distribution of output and earnings effects depends on which export industry is initially affected. Given these advantages, numerous small-area and State-level I-O models were constructed during the 1960's and early 1970's by surveying establishments for industry-specific sales and purchase data. However, not all of these models were of high quality; many were one-time, low-budget efforts, and several studies adopted I-O accounting procedures for the trade sectors that make their use in regional impact analysis questionable.3/ Still, several States (for example, Kansas, Texas, Washington, and West Virginia) maintain an ongoing commitment to producing usable periodic survey-based tables.

One major obstacle to the extensive use of small-area I-O models in regional impact analysis is their cost. For example, Glickman (1977) notes that approximately $250,000 was expended over a 5-year period for the collection and processing of data for the

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1. Glickman (1977) discusses the conceptual basis of economic base models. In addition, he provides a thorough review of regional economic modeling techniques with numerous observations on the advantages and disadvantages of each technique.

2. For detailed presentations of I-O modeling methodology, see Miernyk (1965), Miernyk, et al. (1970), and Bourque and Conway (1977). For summaries and bibliographies of regional I-O modeling techniques, see Richardson (1972) and Giarratani, et al. (1976). Schaffer, et al. (1976) present a thorough discussion of the interpretation and use of regional I-O models.

3. See U.S. Water Resources Council (1977) for a partial bibliography of these tables; the trade sector accounting problems are also discussed in this source. See Bourque and Cox (1970) and Hewings (1970) for additional bibliographies of these early regional tables.

500-industry Philadelphia I-O study. Commenting on the construction of the 1958 Philadelphia table, Isard and Langford (1971) indicate that implementation costs were significant, especially those associated with maintaining experienced research personnel.

During the same period, regional time-series econometric models were estimated for several States and metropolitan areas.4/ In terms of industrial detail, econometric models represent a compromise between the simplistic two-sector economic base model and the industrially disaggregated I-O models. For example, the Tennessee econometric model developed by Gustely (1978) has 23 endogenous industrial sectors. However, econometric models have two major limitations when used for regional analysis. First, the time series data used in constructing econometric models often are available only at the State and metropolitan-area levels, thus typically precluding county-level analysis. Second, like survey-based I-O models, econometric models are costly to build and maintain, particularly in terms of time and experienced research personnel. Thus, unless there is an ongoing need to analyze numerous projects or policy changes in a particular region, it is doubtful that constructing either a survey-based regional I-O model or an econometric regional model is cost effective. Additionally, because of time and research-personnel costs, the various single-region, survey-based I-O models and econometric models are often constructed by differing research teams. Thus, in most cases, the results of these models are not comparable, and interarea comparisons of policy changes are difficult because of the differing conceptual procedures adopted by the various research teams. At the State level, a notable exception is the National-Regional Impact Evaluation System (NRIES), for which the same structure was employed in each State model.5/

Classification of Nonsurvey I-O Techniques

The demand for regional economic models that can be applied at the county level, estimated by using inexpensive techniques and applied across areas for interregional comparisons, often has been met by nonsurvey I-O techniques. These techniques frequently use a national I-O table as a basis for regional technology and then make adjustments that take into account various differences between the region's economy and that of the Nation. According to the specificity of their data input needs, these techniques can be classified into four broad groups.

The first group of techniques estimates regional I-O coefficients, using detailed knowledge of local characteristics derived from data on industries or establishments whose technologies or trading patterns are suspected of differing from their national counterparts. The term, "mixed approach," is adopted in this monograph to describe the first group of techniques, because the regional I-O coefficients can be viewed as a mixture of purely national and purely regional interindustry relationships. As a first example of this group of techniques, the Multiregional Input-Output Model (MRIO) consists of linked I-O models for each State.6/ MRIO is based on the following five data-estimation techniques: (1) detailed, State-specific, interindustry relationships

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4. Glickman (1977), Knapp, et al. (1978), and Ballard, Gustely, and Wendling (1980) provide bibliographies, as well as discussions of the construction and use of regional econometric models.

5. The structural and performance characteristics of NRIES are discussed in Ballard, Gustely, and Wendling (1980).

6. Polenske (1980) summarizes the MRIO model and contains an extensive bibliography of the MRIO project, which began in 1967. It is important to recognize that unlike the other nonsurvey I-O techniques discussed in this monograph, which are exclusively single-region techniques, MRIO provides comprehensive and consistent State economic accounts to be used in multiregional economic analyses.

(obtained from various Federal sources) for a number of industries, (2) State-specific output-weightings of national coefficients for other industries, (3) various estimation techniques based on Federal data sources for construction of the components of final demand, as well as industry-specific totals for output, employment, payrolls, and other measures related to value added, (4) special tabulations of the U.S. Census of Transportation for estimating interstate trade, and (5) reconciliation of the estimates obtained from the preceding four procedures with values from national economic accounts and I-O tables. In several respects, the MRIO methodology for constructing each State I-O table is similar to that used in constructing the national I-O table; that is, while no surveys of establishments are used directly in estimating MRIO or national I-O coefficients, numerous Federal data files are used. Because of the lack of actual data for some necessary components at the State level, when compared to national I-O tables, the MRIO methodology requires a more extensive use of estimation techniques to fill in the missing data.7/ Two major advantages of MRIO are its ability to make interstate comparisons because the same model structure is used in each State, and its ability to identify feedback effects because of State-to-State trade-flow matrices.8/ Two major disadvantages of the current MRIO system are its use of 1963 base-year data for several important components of the model and its inability to perform small-area, substate impact analysis.

As a second example of this approach, the Georgia Economic Model 9/ was estimated by using the national I-O table as a first approximation to the State's table. This table was then adjusted with data on interindustry purchases and sales obtained by surveying a sample of firms. In addition, confidential industry-specific output, employment, and wage data were used to supplement the survey-based data and to serve as a further adjustment to the national table. These confidential data were gathered by various State government administrative agencies as part of their ongoing revenue and expenditure functions.

As a third example, an Australian regional I-O modeling system, termed the Generation of a Regional Input-Output Table (GRIT)10/, applied a number of mechanical procedures to a national I-O table for the purpose of estimating a prototype regional table. The mechanically-produced prototype table was then further regionalized by an analyst who had access to superior, but limited, data on regional interindustry relationships. A newer version of the modeling system, GRIT II, has an "accuracy-optimization" procedure, which can be used to identify the I-O cells that most affect multiplier size. Based on the procedure, an analyst can maximize the accuracy of a regional multiplier matrix, subject to a data-gathering budget constraint.

The mixed approach of modifying a national table with limited survey or other region-specific data may require considerably less data gathering than a purely survey-based table and, therefore, may entail lower associated costs. However, in terms of the

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7. For examples of the data sources and the manipulation techniques used in estimating personal consumption expenditures, see Polenski (1972); for examples of data sources and the manipulation techniques used in estimating interregional trade, see Rodgers (1973).

8. For an example of the advantages of MRIO, see Polenske and Rowan (1977). With respect to these advantages, the MRIO model is similar to the NRIES model mentioned above.

9. Schaffer, et al. (1976) describe the Georgia Economic Model.

10. West, et al. (1979) describe the GRIT and GRIT II procedures; in addition, the study contains a recent and extensive regional I-O bibliography.

need for experienced research personnel, the costs of the two approaches are similar. Thus, with the exception of the MRIO model, the mixed approach of nonsurvey data supplemented with primary data would require a different research team for each area to be studied, and interarea comparisons would be difficult unless each team agreed to use identical procedures. In addition, the mixed approach frequently cannot be applied for small areas because of the unavailability of administrative data for these areas. In these respects, the mixed approach has the same drawbacks as a purely survey-based methodology. In fact, tables that are viewed as "purely" survey-based often are based partially on extensive use of administrative records, especially for estimating control totals for industry-specific output. Moreover, Jensen (1980) argues that the purely survey component of some "survey-based" tables has not been sufficiently large to warrant their being considered as true survey-based tables. In application, the difference between "purely" survey-based and mixed-approach tables could be small. As a consequence, previous studies have not compared the results of the mixed approach with those from "purely" survey-based tables.

The second broad group of national table adjustment procedures--the constraining of national technical coefficients, based on region-specific information--also requires a significant survey element. The RAS technique is an example of this type of adjustment procedure. The RAS technique was originally developed by Stone and Brown (1965) for projecting national technical coefficients with limited survey data; it has also been used to estimate regional tables.11/ In the regional applications of the RAS technique, national coefficients are constrained to regional industry-specific intermediate output and input control totals. As applied by Morrison and Smith (1974), the control totals were obtained from survey data. While the RAS technique requires less primary data than the mixed approach, its data gathering costs often preclude its being applied in many small-area impact analyses, especially for a one-time set of changes in final demand.

Several evaluations of the accuracy of the RAS technique have been performed. Morrison and Smith found that their semisurvey RAS approach generated Type II income multipliers that averaged 7 percent above the survey-based table estimates for the City of Peterborough, England.12/ However, Miernyk (1976) summarizes other research results that indicate that the RAS technique is less accurate. In addition, Hewings (1977) questions the industry-specific reliability of the RAS technique as well as the expense in gathering the data necessary for its use, although he generally confirms the aggregate validity of the technique.

A third group of techniques for adjusting the national tables to generate regional tables can be used with no survey data, but it makes use of economic data gathered by the Federal Government. For example, a methodology proposed by Stevens and Trainer (1980) uses the Bureau of Labor Statistics' Consumer Expenditure Survey and the Bureau of the

11. For a more recent description of the RAS technique see Bacharach (1970); for a discussion of its use with survey-based regional I-O tables see Malizia and Bond (1974). While McMenamin and Haring (1974) have refined the RAS procedure, their refinements, although lessening the data requirements, are only applicable to the problem of updating an earlier table. For many small areas, there is no earlier table to update.

12. Type II income multipliers are based on an I-O model with an endogenous household sector, while Type I income multipliers are based on an I-O model with an exogenous household sector. A detailed discussion of the distinction between Type I and Type II I-O multipliers can be found in Richardson (1972) and Schaffer, et al. (1976). Several aspects of the relationship between the household sector and the definitions of I-O multipliers are discussed in chapter 4 of this monograph.

Census' regional economic data (especially, the Census of Transportation) for altering technical coefficients in the national table. For some States and metropolitan areas, these data are similar to those that would be gathered in an industry survey. For smaller areas, where there is a lack of data due to establishment confidentiality problems and incomplete tabulation of industry-specific data, Stevens and Trainer advocate the use of various estimation techniques to fill in the missing data. For example, Stevens and Trainer use regression techniques with ratios of weight to value of shipments, population density, and income as independent variables to explain industry-specific imports and exports.13/ In addition, they estimate output in some sectors as a function of County Business Patterns employment data; these employment data often must be estimated for detailed sectors as functions of more aggregate, but disclosed, subtotals.

This third group of nonsurvey techniques is similar to the first group; the major difference is that the adjustment data employed by the third group are not survey-based and often must be estimated for a particular study area.14/ This group of techniques avoids the large costs of gathering survey data and can be applied on a consistent basis to many small areas for interregional comparisons. However, there are two potential problems with this group of techniques. First, since Census data often are available only every 5 years, estimating current import levels in regional tables may be difficult. Second, much of the data actually used in adjusting national tables to small-area tables are estimated by regression equations that are specified by the use of State or metropolitan-area data for aggregated industry control totals. The estimated data, therefore, may not reflect actual relationships at the small-area level. However, in spite of these potential problems, Stevens, et al. (1980) reported generally favorable results in comparing their technique with the 1972 Washington State survey-based table; for example, the average value-added and column-total multipliers were 4 percent higher than the corresponding survey-based multipliers.15/

The fourth group of national-table adjustment techniques makes use of generally available published data on industry-specific employment or earnings to estimate the level of industry-specific imports. The national table is then adjusted to the regional level by taking into account these imports. The major advantages of these techniques are their low application cost, and their ability to be applied even at the county level when making interarea multiplier comparisons.

The LQ and the supply-demand pool techniques, as described in studies by Schaffer and Chu (1969), Schaffer (1972), and Morrison and Smith (1974), are examples of the fourth group of techniques. In comparing the LQ and supply-demand pool techniques with survey-based tables, the studies indicate that the simple LQ technique is the most accurate of the nonsurvey techniques analyzed. However, the average multiplier generated by this LQ technique is considerably higher than the average multiplier estimated from the survey-based tables. For example, Schaffer and Chu found that the average simple LQ Type II income multiplier was 47 percent higher than the survey-based multiplier, and Morrison and Smith found that it was 27 percent higher.

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13. Stevens, et al. (1979) present several refinements to the estimation techniques developed by Stevens and Trainer.

14. However, Stevens and Trainer (1980) do argue that if limited survey funds are available, they should be used to estimate likely direct ("first round") effects. See also Conway (1977) on this point.

15. The inversion RIMS II results presented in chapter 5 of this monograph are similar to those reported by Stevens, et al. (1980).

Previous BEA Research

Several researchers at BEA have undertaken studies of the feasibility of using techniques that can be classified in this fourth group. Walderhaug (1972) constructed a synthetic technical coefficient table for Washington State. Using the 367-industry national technical-coefficient table for 1963, he aggregated the 270 industries present in the State to the 27 sectors identified in the Washington State table. He concluded that the differences between the synthetic and survey-based technical coefficients were within an acceptable range.16/

Garnick (1970) demonstrated that there are inexpensive techniques for augmenting basic-service multipliers so that industry-specific multipliers can be estimated. Using 2-digit SIC BEA earnings data and an 80-sector 1963 national technical-coefficient I-O table, he estimated industry-detailed economic base multipliers for two States for which survey-based I-O tables existed (Washington and Nebraska). He found that, with the exception of resource-oriented industries in both States, most differences between the two estimates appeared to be within tolerable limits. For example, for 18 directly comparable sectors in the 1963 Washington table, the average difference between the survey-based I-O Type II income multiplier and its augmented basic-service counterpart was 10 percent of the survey multiplier.

Drake (1976) combined Walderhaug's use of a very disaggregated sectoring plan and an extension of Garnick's relationship between direct (basic) effects and indirect-induced (local-service) effects. The resulting model, RIMS, employed (1) a variation of the 2-digit SIC LQ approach, to estimate the direct component, and (2) a regression equation based on survey-based tables, to estimate the indirect-induced component of the multiplier for each industry.

To date, at least two studies, comparing RIMS multipliers with those from survey-based tables, have been undertaken. Among his other findings, Drake (1976) reported that RIMS underestimated the mean multiplier for the New Mexico State model by 22.5 percent and overestimated the mean multipliers for the St. Louis SMSA and Nebraska State models by approximately 17 percent. Using an aggregate 86-industry national table, Latham and Montgomery (1977) compared the results of two nonsurvey techniques (simple LQ's and RIMS) with the 1969 survey-based Kansas table. They found RIMS Type II gross-output multipliers outperformed the simple LQ multipliers, although both techniques recorded substantial errors when compared with survey-based table multipliers. For example, the average RIMS multiplier overestimation was 18 percent of the survey-based model multiplier, while the simple LQ multiplier overestimation was 26 percent.

The orginial version of RIMS represented an inexpensive nonsurvey technique that could be generalized to any county-defined study area. However, there are at least three limitations associated with RIMS. First, unlike some nonsurvey models, RIMS could estimate only column-total multipliers. Thus, for a given initial final-demand change,

16. Bourque (1972) noted that, because Walderhaug did not estimate import and export flows, his synthetic table could not be inverted to estimate State multipliers for use in impact analysis.

the industrial distribution of total effects could not be specified.17/ Second, as Miernyk (1976) comments, the differences between survey-based I-O multipliers and RIMS multipliers still may be too large for RIMS' widespread use in economic impact analysis. Third, since RIMS was initially developed in the mid-1970's, more recent and detailed data have become available, including a 1972 national I-O table and 4-digit SIC wage and salary estimates at the county level. The refinements to the original version of RIMS, which were incorporated in RIMS II to avoid the three limitations, are discussed in the remainder of this monograph.

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17. Several nonsurvey techniques permit the estimation of a full I-O transactions table. The fourth group of nonsurvey techniques is generally used only for estimating the direct-coefficient and multiplier matrices. The RIMS technique was originally developed only for estimating the individual column totals of the direct-coefficient and multiplier matrices. However, an approximation procedure for estimating RIMS earnings and employment effects was developed at BEA. This procedure can be found in U.S. Water Resources Council (1977); the procedure is also discussed in chapter 4 of this monograph.

Chapter 3

ESTIMATION OF THE REGIONAL DIRECT COEFFICIENTS

All purely nonsurvey techniques take a national I-O table as a first approximation of regional interindustry relationships. The national table can then be made region specific by removing those input requirements that are not produced in the region. The focus of this chapter is on the algebraic derivation of the national direct-requirements matrices, the regionalization of these matrices by several LQ techniques, and the estimation of row and column coefficients for the household sector. A brief discussion of the aggregation of the resulting regional table then follows. The chapter concludes with a summary description of how RIMS II estimates regional direct coefficients.

Derivation of the National Tables

In order to provide more information on the I-O structure of the economy (especially in terms of an industry's production of secondary products), the 1972 national I-O tables differ from earlier national benchmark tables in terms of definitions and conventions. For this reason, a detailed derivation of the national tables is useful for indicating explicitly how the national I-O tables provide the basis for estimating regional I-O tables.1/ This discussion of the national I-O tables concludes by showing the relationship between the detailed derivation's matrix notation and the more familiar I-O matrix notation, which is used elsewhere in this monograph in order to simplify the presentation of RIMS II.

The derivation of the national table begins with two accounting identities that define total commodity and industry output. The total national output of a given commodity can be defined as:

$$q = Ui + e \tag{3.1}$$

where:

- q = a column vector showing total output by commodity
- U = the intermediate portion of the commodity-by-industry input matrix
- i = a unit vector
- e = a column vector showing total final demand purchases by commodity

Similarly, the total national output of a given industry can be defined as:

$$g = Vi + h \tag{3.2}$$

where:

- g = a column vector showing total output (including scrap) by industry

1. The derivation of national I-O tables is taken from Ritz (1980). For additional details on the national I-O tables, see Ritz (1979) and Ritz, et al. (1979).

V = the industry-by-commodity output matrix with zero-filled columns for noncomparable imports and scrap2/

h = a column vector showing the total output of scrap by industry

In order to convert the accounting identities of equations 3.1 and 3.2 into an economic model that determines the levels of industry and commodity output, the following three assumptions are made:

(1) If inputs are required in proportion to output and the proportions are the same for an industry's primary and secondary products, then

$$U = Cg^* \quad \text{3/} \tag{3.3}$$

where:

C = a technical-coefficients matrix showing the amount of a commodity used by an industry per dollar of output of that industry

(2) If each commodity (other than scrap) is produced by the various industries in fixed proportions, then

$$V = Dq^* \tag{3.4}$$

where:

D = a market-share matrix showing for a given commodity (excluding scrap) the proportion of the total output of that commodity produced in each industry4/

(3) If scrap output in each industry is proportional to total output of the industry, then

$$h = p^*g \tag{3.5}$$

where:

p* = a square matrix with the ratio of the value of scrap produced in each industry to the total output of the industry on the main diagonal and zeros elsewhere

Equations 3.1 through 3.5 represent an I-O model with three constants (C, D, and p), five endogenous variables (U, V, h, q, and g), and one exogenous variable (e). A model solution which relates total output and final demand can be derived as follows:

Substituting 3.4 into 3.2 yields:

$$g = Dq + h$$

$$g - h = Dq \tag{3.6}$$

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2. This treatment of scrap prevents its requirement as an input from generating output in the industries in which it originates.

3. An asterisk (*) associated with the symbol for a vector indicates a square matrix in which the elements of the vector appear on the main diagonal and zeroes are entered elsewhere.

4. To allow for leakages from the domestic economy, D is defined here to include comparable imports.

Substituting 3.5 into 3.6 and solving for g yields:

$$g - p^*g = Dq$$

$$(I - p^*)g = Dq$$

$$g = (I - p^*)^{-1}Dq \qquad (3.7)$$

where:

I = the identity matrix

To simplify the notation, if $W = (I - p^*)^{-1} D$, then

$$g = Wq \qquad (3.8)$$ 5/

Then, substituting 3.3 into 3.1 yields:

$$q = Cg + e \qquad (3.9)$$

Multiplying 3.9 by W and substituting 3.8 into this result yields:

$$g = WCg + We \qquad (3.10)$$

Solving for g yields:

$$g = (I - WC)^{-1}We \qquad (3.11)$$

The final model solution shown in equation 3.11 indicates the relationship among total output by industry (g), the direct-requirements matrix (WC), and the final demand vector (e). In that equation the expression WC is an industry-by-industry direct-requirements matrix for the Nation, and the expression $(I - WC)^{-1}$ is an industry-by-industry total-requirements matrix. Further, the multiplication of the final demand vector e by the W matrix has the effect of converting commodity demand into industry demand.

The national I-O model described above is flexible in the sense that it can be used to derive variously-defined regional I-O models. For example, when comparing nonsurvey with survey regional tables, the national industry-by-industry matrix derived here is the appropriate starting point, since regional survey tables are typically constructed on an industry basis.6/ However, when regional final demand is stated in terms of commodities rather than industries, an industry-by-commodity matrix is more appropriate.7/

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5. Since the matrix $(I - p^*)^{-1}$ has values ≥ 1 on the main diagonal, $W_{ij} \geq D_{ij}$ for all i,j; the difference between W_{ij} and D_{ij} is the dollar value of scrap output generated by industry i in producing its share of one dollar's worth of commodity j.

6. Establishments are classified by industry according to their primary activities in the three survey-based tables examined in this study.

7. An industry-by-commodity total-requirements matrix is derived as follows: Substituting (3.8) into (3.9) and solving for q yields:

In order to generalize and simplify the presentation of RIMS II, a more familiar I-O matrix notation is used in the remainder of this monograph, even though RIMS II is based on the flexible I-O model described in equations 3.1 through 3.11. In this more familiar notation, interindustry or intercommodity relationships are represented by the following equation:

$$X = AX + Y \tag{3.12}$$

where:

X = a column vector of gross output
A = a matrix of direct requirements coefficients
Y = a column vector of final demand

Equation 3.12 states that total output (X) equals intermediate sales (AX) plus final sales (Y).8/ The dimensions of the square A matrix are equal to the total number of industries or commodities specified. Thus, for example, the direct industry requirements matrix can be represented by the following equation:

$$A = \left[a_{ij}\right] \tag{3.13}$$

where:

i,j = 1,2,...., n intermediate industries

At this point, it is useful to describe the relationship between the notation in equations 3.1 through 3.11 and the more familiar notation in equations 3.12 and 3.13. For example, in equation 3.9, output and input are represented by q and g, while in equation 3.12, output and input are represented by X. Similarly, A corresponds to either of the matrix products (CW or WC) and Y corresponds to e or We. The relative complexity of the I-O model described by equations 3.1 through 3.11 is caused by this model's explicit treatment of the primary and secondary commodity output of each industry. Since the model expressed by equations 3.12 and 3.13 is defined exclusively on an industry basis, its notation can be considerably less complex.

The discussion in the remainder of this monograph uses the more familiar matrix notation in equations 3.12 and 3.13, even though the national I-O model underlying RIMS II is expressed in equations 3.1 through 3.11. This less complex notation is adopted for three reasons. First, the less complex notation simplifies the presentation and, therefore, allows emphasis to be placed on the regionalizing techniques. Second, the less complex notation generalizes the discussion of the regionalizing techniques. Thus,

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$$q = (I - CW)^{-1}e \tag{3.11a}$$

where $(I - CW)^{-1}$ is a commodity-by-commodity total-requirements matrix. Substituting (3.11a) into (3.8) yields:

$$g = W(I - CW)^{-1}e \tag{3.11b}$$

where $W(I - CW)^{-1}$ is an industry-by-commodity total requirements matrix.

8. See chapter 2, footnote 2, for references to studies that use this more conventional I-O notation.

the A matrix can refer to either the industry-by-industry direct-requirements matrix (WC) or the commodity-by-commodity direct requirements (CW). Third, the less complex notation permits an easier comparison of RIMS II with previous regional I-O techniques. For example, the comparison of the multipliers from RIMS II and the survey-based tables presented in chapter 5 of this monograph must be performed on A matrices, which are defined on an industry-by-industry basis, since the survey-based tables adopt this convention.

Regionalization of National Coefficients

As indicated in chapter 2, several nonsurvey approaches can be used to adjust national I-O coefficients. Of these approaches, the LQ technique is most often used, since the data used to construct LQ's are often readily available. As shown by Schaffer and Chu (1969) and others, these LQ's can be defined in several ways. The most straightforward form, the simple location quotient approach (SLQ), assumes that the needs of regional industries for output in each industry i relative to the needs for output in each of these industries nationally are the same as the ratio of total regional to total national output. In addition, several variations in the form of the LQ have been used.9/ One approach (the purchases-only LQ) defines the base of the LQ to be the outputs of those industries purchasing inputs from industry i instead of total regional and national outputs. Another approach (the cross-industry LQ) allows the import proportions to vary within rows by comparing the proportion of national output of selling industry i in the region to that of purchasing industry j in the region. However, past studies (summarized in chapter 2) of the accuracy of these alternatives indicate the relative superiority of the SLQ approach.

A simple location quotient for each regional industry can be defined by the following equation:

$$SLQ_i = \frac{Q_i^r/T^r}{Q_i^n/T^n} \tag{3.14}$$

where:

Q_i^r = a measure of the output of industry i in region r

Q_i^n = a measure of the output of industry i in the Nation

T^r = a measure of aggregate economic activity in region r

T^n = a measure of aggregate economic activity in the Nation

Data on earnings or employment by industry are often used to specify Q_i^r and Q_i^n ; data on total income, population, earnings, or employment are used to specify T^r and T^n.

Simple LQ's are one measure of the region's self-sufficiency in producing the output of a given industry. Referring to equation 3.14, an LQ of less than 1.0 means that the output of regional industry i represents a smaller share of regional economic activity than the output of national industry i represents of total national activity. Accordingly, LQ's are often used to identify regional industries that are net importers and exporters. Thus, if SLQ_i is less than one, the region imports some of the output of

9. See Richardson (1972) and Schaffer and Chu (1969) for a more detailed discussion of these variations.

industry i from elsewhere in the Nation. Similarly, if SLQ_i is greater than one, the region exports some of the output of its industry to the rest of the Nation. If SLQ_i equals one, the region, on a net basis, neither imports nor exports the output of industry i, and the region is viewed as self-sufficient with respect to industry i's output.

The region's SLQ's are often used to regionalize the national I-O table in the estimation of the regional direct-purchase coefficients. This can be expressed by the following equation:

$$a_{ij}^{r} = SLQ'_i \quad a_{ij}^{n} \tag{3.15}$$

where:

a_{ij}^{r} = the proportion of the total output of the regional industry j that is accounted for by the purchases of inputs from regional industry i

a_{ij}^{n} = the national direct-requirements coefficient

$$SLQ'_i = \begin{cases} SLQ_i \text{ if } SLQ_i \\ 1.0 \text{ if } SLQ_i \end{cases}$$

Thus, in those cases where SLQ_i is less than one, a_{ij}^{r} is less than a_{ij}^{n} for all j industries. The positive difference between a_{ij}^{n} and a_{ij}^{r}, when SLQ_i is less than one, is a measure of the extent of importing the i^{th} industry's output. Similarly, if SLQ_i is greater than or equal to one, then a_{ij}^{r} and a_{ij}^{n} are equal, and the region is assumed to be self-sufficient in producing the i^{th} industry's output.10/

The conceptual problems associated with the use of the SLQ technique (as well as the other LQ techniques) are well documented.11/ The effects of some of these limitations can be lessened by the choice of the basis upon which the LQ is to be determined. For example, Nourse (1968) and others have argued that earnings-based LQ's take better account of regional productivity differences than do employment-based LQ's.

Another limitation, that resulting from regional differences in industrial mixes, can often be due to the lack of adequate regionalizing data. For example, while the national I-O table is based on a 4-digit SIC classification scheme, industry-specific regional employment or earnings data are often available only at a more aggregate level. Therefore, regionalizing with aggregate LQ's ignores the differences between the region's and the Nation's disaggregated industry-specific output mix. For

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10. In the notation of equations 3.1 through 3.11, the regional industry-by-industry direct requirements matrix is (SLQ* WC), and the regional commodity-by-commodity direct requirements matrix is (C SLQ* W), where SLQ* is a diagonal matrix with the vector SLQ'_i on the main diagonal and zeros elsewhere.

11. Isard (1960) and Nourse (1968) discuss in more detail the limitations of using LQ's for estimating imports and exports.

example, aggregate LQ's are often defined on the basis of 2-digit SIC data. At this level of classification, approximately 60 industry-specific LQ's can be identified for regionalizing the national I-O table. Thus, SLQ_i in equation 3.14 is defined where i is equal to 1 through 60. However, since the most disaggregated national table consists of 496 industries, the use of only 60 SLQ_i's in equation 3.15 means that the same SLQ_i is often used for many disaggregated industries.12/ The effect of the use of only 60 SLQ_i's is that the national and regional I-O tables (described in equation 3.15) have only 60 industries. Given the availability of more industrially disaggregated data, disaggregated SLQ_i's would seem to be more appropriate than aggregated SLQ_i's for estimating regional I-O tables. For example, using SLQ_i's for each industry in the national I-O table, 496 SLQ_i's (rather than only 60 SLQ_i's) would be used in estimating a matrix of regional direct-purchase coefficients at the 496-industry level.13/

A third limitation of some LQ's (notably earnings and employment LQ's) results from their failure to adequately reflect the regional level of aggregate demand. Earnings-based LQ's are widely used to identify regional imports, and they function as proxies for industry output and demand. However, for estimating the level of regional self-sufficiency in providing certain industry-specific outputs, Isard (1960), Nourse (1968), and Stevens and Trainer (1980) have argued that personal income-based LQ's are more appropriate.14/ Specifically, when a large part of an industry's output is sold directly

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12. For example, food manufacturing (SIC 20) is one 2-digit SIC industry, yet 44 food manufacturing industries are identified in the disaggregated national I-O table. For the application presented in chapter 6 of the monograph, the Denver SMSA's SLQ for SIC 20 is greater than 1.0, yet the disaggregated SLQ's for the 44 food manufacturing industries range from 0.0 to over 9.0; 14 of these SLQ's are zero, and 17 others are less than 1.0. Thus, the use of aggregate SLQ's overstates Denver's level of self-sufficiency in 31 disaggregated food manufacturing industries.

13. The original RIMS used a combination of aggregate and disaggregate SLQ's. In the original RIMS, County Business Patterns (CBP) data at the 4-digit SIC level were used to identify industries that were not present in the region; SLQ's for these industries were set equal to zero. SLQ's for the remaining industries were based on BEA's 2-digit SIC county earnings data. The reason for this combined approach is that the CBP data, while tabulated at the 4-digit SIC level, do not present employment or earnings estimates for many industries present in a given county because of disclosure regulations. Recently, the wage and salary component of BEA's county-earnings data base has been expanded to the 4-digit SIC level. While the expanded data base is subject to disclosure regulations and is not available for public use, it is used in RIMS II calculations.

14. Earnings consist of wages and salaries, other labor income, and proprietors' income. Personal income consists of earnings, plus transfer payments, dividends, interest, and rent, less personal contributions for social insurance. For details on the definitions and measurement of personal income at the regional level, see U.S. Department of Commerce (1980).

Earnings-based LQ's are defined as:

$$SLQ_i = \frac{E_i^r / TE^r}{E_i^n / TE^n} \tag{3.14a}$$

to final demand, personal income LQ's may be more accurate than earnings LQ's in estimating regional self-sufficiency (and therefore imports).15/ For example, in a region where transfer payments are proportionately larger than in the Nation, retail trade self-sufficiency will be better estimated by a personal income LQ than an earnings LQ. This is because the personal-income-based LQ accounts for all sources of intermediate and final demand for retail trade, while the earnings-based LQ accounts for only the earnings-based demand for retail trade.

Since LQ's function as proxies for regional output and demand, the appropriate LQ should be based on the regional source of demand for output. Therefore, a mixed-LQ approach that combines the use of earnings-based and personal income-based LQ's should be useful in estimating regional purchase coefficients.16/ Thus, for industries that sell most of their output to intermediate demand, an earnings LQ may be more appropriate; in this case the level of regional total earnings would be a proxy for the level of total intermediate output. However, for industries that sell most of their output to final demand, a personal income LQ may be more appropriate; in this case the level of regional personal income would be a proxy for the level of final demand.

Endogenizing Households

When it is appropriate to indicate the effects of output changes in personal income or earnings, the direct-regional-purchase-coefficients matrix (A^r) is expanded in

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where:

E_i^r, E_i^n = earnings in industry i in the region and the Nation, respectively

TE^r, TE^n = total earnings in the region and the Nation, respectively

Personal income-based LQ's are defined as:

$$SLQ_i = \frac{E_i^r/PY^r}{E_i^n/PY^n} \qquad (3.14b)$$

where:

PY^r, PY^n = total personal income in the region and the Nation, respectively

15. For an example of the use of personal income LQ's see Cartwright (1979), where, on the basis of earnings LQ's, most suburban areas appeared self-sufficient in providing retail trade and other service-type outputs. However, on the basis of personal income LQ's, several suburban areas imported these services. The positive difference between earnings LQ's and personal income LQ's occurred because of the large positive residence adjustment component (that is, income earned in the urban central county by suburban residents) of suburban personal income.

16. For any given industry, it is impossible to construct an accurately mixed LQ without data on the total intermediate and final sales that are specific to that regional industry. As used in chapters 5 and 6 of this monograph, the RIMS II LQ's for the agriculture, mining, and manufacturing industries are equal to the earnings LQ's. The RIMS II LQ's for the remaining industries are equal to the personal income LQ's.

regional I-O analyses by the inclusion of a regional household row and a household column. Often A^r is expanded to include the household sector when an analyst wants to indicate the additional effects induced by consumer spending as well as the direct and indirect interindustry effects.17/ Based on equation 3.13, the expanded regional matrix can be represented by the following equation:

$$A^r = a^r_{ij} \tag{3.16}$$

where:

$$i,j = 1,....n,n + 1$$

The inclusion of households in A^r requires specifying the regional household-payments-row coefficients ($a^r_{n+1,j}$) and the regional household-expenditure-column coefficients ($a^r_{i,n+1}$).18/ Regional I-O models defined by equation 3.16 are often referred to as "closed with respect to households," and many regional I-O studies refer to A^r (as defined in equation 3.16) as having an endogenous household sector.

The discussion of endogenizing households presented below indicates how the national I-O tables' personal-consumption-expenditure (PCE) column can be adjusted to estimate $a^r_{i,n+1}$, and how the national I-O table's value-added (VA) row can be adjusted to estimate $a^r_{n+1,j}$.

Regional household expenditure coefficients

A region's household coefficient column can be represented by the following identity:

$$1.0 = a^r_{m,n+1} + a^r_{s,n+1} + a^r_{t,n+1} + \sum_{i=1}^{n+1} a^r_{i,n+1} \tag{3.17}$$

where:

$a^r_{m,n+1}$ = the household import coefficient

$a^r_{s,n+1}$ = the household savings coefficient

$a^r_{t,n+1}$ = the household direct tax coefficient

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17. For a discussion of alternative treatments of households, see Schaffer, et al. (1976), Richardson (1972), and others mentioned in chapter 2 of this monograph. The effects of including the household sector on multiplier interpretation and size are discussed in chapter 4 of this monograph; the assumptions associated with an endogenous household row and column are discussed in chapter 6.

18. The cells of the household row ($a^r_{n+1,j}$) show the proportion of the total gross output of industry j that is accounted for by payments to households in the form of labor earnings or value added. The cells of the household column ($a^r_{i,n+1}$) show the industry-specific disposition of personal consumption expenditures per dollar of income by households.

Equation 3.17 states, in coefficient form, that imports, savings, direct personal tax payments, and total intraregional purchases sum to one. For use in most regional I-O analyses, the imports, savings, and tax coefficients represent leakages from the regional economy.19/

The LQ techniques described above can be used to regionalize the national PCE column, and, therefore, to estimate $a^r_{i,n+1}$, as described in equation 3.17. This approach assumes that the national consumption pattern is an appropriate proxy for the regional consumption pattern; it is also consistent with using national technology as a proxy for regional technology in estimating the other portions of the matrix.20/

However, since the national PCE coefficient column is not defined to take into account explicitly personal taxes and savings, the national PCE column first is made region-specific by adjusting for these two leakage effects.21/ This is expressed in the following equation:

$$\hat{a}^r_{i,n+1} = a^n_{i,n+1} (1 - T^r) C^r \tag{3.18}$$

where:

$\hat{a}^r_{i,n+1}$ = an initial estimate of the regional household-column coefficient

T^r = the average regional tax rate

C^r = the average regional aftertax consumption rate

For use in equation 3.18, T^r is the ratio of regional disposable personal income (DPI) to personal income, and C^r is the ratio of national PCE to DPI.22/ In equation 3.18, the

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19. See Bourque and Conway (1977), Grubb (1978), and Loviscek, et al. (1979), for examples of the treatment of personal taxes and savings with respect to regional household expenditures in survey-based regional I-O tables.

20. Stevens and Trainer (1980) use Bureau of Labor Statistics Consumer Expenditure Survey (CES) data for constructing area-specific household column coefficients. However, for many areas CES data are not available, and the regional household column must be estimated from more industrially and geographically aggregated CES control totals. BEA is developing, at the State level, detailed PCE estimates, which can be used for constructing more region-specific household columns.

21. The 1972 national I-O table is constructed with the household sector as part of final demand, and, therefore, its treatment of taxes and savings differs from that in many regional I-O tables.

22. National data are used to estimate C^r, since regional PCE data are not presently available. However, since DPI, at the State level, is estimated by BEA, T^r will vary across States. Furthermore, since T^r varies across States, it is important to recognize that State I-O multipliers also will vary if only because of differences in the level of T^r across States. To some extent, this is due to the lack of endogenous State and local government sectors in most regional I-O models. However, since import leakage differences across States are significantly larger than differences in T^r, the extent to which I-O multipliers vary is far greater for import leakage differences than for T^r differences.

reduction of each national PCE coefficient ($a^n_{i,n+1}$) by average tax and consumption rates provides estimates of the sum of $a^r_{t,n+1}$ and $a^r_{s,n+1}$ in equation 3.17.

By the SLQ technique, $\hat{a}^r_{i,n+1}$ can be used to estimate $a^r_{i,n+1}$. This is represented in the following equation:

$$a^r_{i,n+1} = SLQ'_i \ \hat{a}^r_{i,n+1} \tag{3.19}$$

In equation 3.19, the regionalization of the household column by SLQ'_i corresponds to the regionalization of the other interindustry columns expressed by equation 3.15, where SLQ'_i is based on the mixed-LQ concept, as specified in equations 3.14a and 3.14b. When combined with the estimate of the sum of $a^r_{t,n+1}$ and $a^r_{s,n+1}$ from equation 3.18, equation 3.19 provides an estimate of $a^r_{m,n+1}$ in equation 3.17. Therefore, equations 3.18 and 3.19 describe how the national PCE column can be used to estimate the regional household-coefficient column.

Regional household-payment coefficients

In specifying the household row ($a^r_{n+1,j}$) some regional I-O multiplier formulations use a value added definition, while others use an earnings definition. Since value added is greater than earnings, coefficients based on a value-added definition are larger than those based on an earnings definition.23/ Bourque and Conway (1977) argue that the choice of a household-row definition should be made in the context of the type of impact to be studied.24/ The regional value-added household-row ($a^r_{n+1,j}$) can be estimated by the industry-specific value added-to-gross output ratios from the national I-O table.

The earnings household row is more difficult to estimate using national data. Ideally, the procedure used to construct the earnings household row would use proprietors' income data, wage and salary-to-employee compensation ratios, and disaggregate employee compensation-to-value added ratios for 1972. However, disaggregate ratios are not yet available for the 1972 table. Since only aggregate ratios are available for 1972, disaggregate ratios from the 1967 national table can be

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23. Value added is defined as the sum of employee compensation, profit-type income, and indirect business taxes. Earnings is defined as the sum of wages and salaries (a part of employee compensation), other labor income (another part of employee compensation), and proprietors' income (a part of profit-type income).

24. When using a value-added household-row definition, Bourque and Conway (1977) estimated the household column coefficients ($a^r_{i,n+1}$) by the household industry-specific purchases-to-total regional value added ratio ($X^r_{i,n+1}/VA^r$). When using an earnings household-row definition, the household-column coefficients are estimated by the household industry-specific purchases-to-total regional personal income ratio ($X^r_{i,n+1}/PY^r$).

controlled to the level of the corresponding aggregate 1972 ratios by a procedure such as the following:25/

$$CV_j^{72} = \frac{CV_k^{72}}{CV_k^{67}} \quad CV_j^{67} \tag{3.20}$$

where:

CV = an employee compensation-to-value added ratio

In equation 3.20 and other equations presented below, the superscripts (67 and 72) refer to the base years of the national I-O tables; the subscript j refers to an industry in the 496-industry-level national table, and the subscript k refers to the industry of which j is a part in the 85-industry-level national table. In equation 3.20, the distribution of the 1967 employee compensation-to-value added ratios for disaggregate industries is used to allocate the 1967 to 1972 corresponding aggregate industry change in those ratios.

The employee compensation ratios estimated for 1972 can then be further adjusted to reflect the exclusion from earnings of compensation other than wages and salaries and other labor income, and the inclusion in earnings of proprietors' income. Such an adjustment can be represented as:

$$EV_j^{72} = CV_j^{72} \quad WO_k^{72} \quad PW_k^{72} \tag{3.21}$$

where:

EV = the national earnings-to-value added ratio
WO = the national wages and salaries and other labor income-to-employee compensation ratio
PW = the national proprietors' income and wages and salaries-to-wages and salaries ratio

In equation 3.21, WO is always less than one, because the sum of wages and salaries and other labor income is less than employee compensation; PW is greater than one for most industries, because proprietors' income is positive in most industries.

Finally, earnings-to-gross output ratios can be estimated as follows:

$$EG_j^{72} = EV_j^{72} \quad VG_j^{72} \tag{3.22}$$

where:

EG = the national earnings-to-gross output ratio
VG = the national value added-to-gross output ratio

25. Employee compensation-to-value added ratios for the 484-industry-level 1967 national I-O table can be found in Coughlin (1978). Employee compensation-to-value added ratios for the 85-industry-level 1972 national I-O table can be found in Ritz (1979) and Ritz, et al. (1979). When employee compensation-to-value added ratios for the 496-industry-level 1972 I-O table are available, they will be used directly in equation 3.21.

Thus, in cases where an earnings-defined household row is relevant, $a^n_{n+1,j}$ is defined by the following equation:

$$a^n_{n+1,j} = EG^{72}_j \tag{3.23}$$

In other cases, where a value-added household row is relevant, $a^n_{n+1,j}$ is defined by the following equation:

$$a^n_{n+1,j} = VG^{72}_j \tag{3.24}$$

Whether a value-added or an earnings household-row definition is adopted, it is important to adjust the household row to reflect the region's loss of income that results from individuals working in the region but residing outside the region.26/ Thus, commuters' income is viewed as a leakage from the regional economy. This additional adjustment is represented as follows:

$$a^r_{n+1,j} = SLQ_{n+1} \; a^n_{n+1,j} \tag{3.25}$$

where:

SLQ_{n+1} = total personal income plus residence adjustment divided by total personal income, if residence adjustment is negative

SLQ_{n+1} = 1.0, if residence adjustment is not negative

In equation 3.25, the amount of residence adjustment is used as the basis for constructing an LQ (SLQ_{n+1}) to estimate the size of a region's labor imports.

Industry Aggregation

Previous sections of this chapter have described various techniques for estimating a disaggregated regional direct-purchase-coefficient (a^r_{ij}) matrix. However, a more aggregated coefficient (a^r_{lm}) matrix is often useful.27/ Ideally, since the coefficients to be aggregated are defined in terms of output, columns of a disaggregated direct-coefficient matrix should be aggregated on the basis of industry-specific output data. However, since these data seldom are available at the regional level, industry-specific earnings data can be used to estimate proxies for regional output. This is represented in the following equation:

$$X^r_j = \frac{E^r_j}{E^n_j} X^n_j \tag{3.26}$$

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26. For a discussion of the residence-adjustment concept, and its relationship to commuting, see U.S. Department of Commerce (1980.)

27. For example, in the accuracy comparisons presented in chapter 5 of this monograph, the nonsurvey matrices were aggregated to a level of industry detail which is comparable to that of the survey-based matrices. In addition, an aggregated matrix may be appropriate, since impact studies may not require the industry detail provided in the national table. This is especially true for the row industry detail. For the application of RIMS II presented in chapter 6, the 496 rows of the regional matrices have been aggregated to 39 rows.

where:

X_j^r = a proxy for the output of industry j in region r

X_j^n = the output of industry j in the Nation

E_j^r = earnings in industry j in region r

E_j^n = earnings in industry j in the Nation

In equation 3.26, for each disaggregated industry the regional share of national earnings estimates a proxy for regional output to be used in the following aggregation procedure.28/

In order to aggregate a matrix with j columns to one with m columns, the following equation can be used for all i rows:

$$a_{im}^r = \frac{\sum_{j=j'}^{j''} a_{ij}^r \; X_j^r}{\sum_{j=j'}^{j''} X_j^r} \tag{3.27}$$

where:

j',...,j" are the disaggregated industries associated with aggregate industry m

In equation 3.27, the disaggregated column coefficients are weighted by the corresponding regional output proxies and then summed to form the aggregate coefficients.

In order to aggregate a matrix with i rows to one with l rows, the following equation can be used for all m columns:

$$a_{lm}^r = \sum_{i = i'}^{i''} a_{im}^r \tag{3.28}$$

where:

i',...,i" are the disaggregated industries associated with the aggregate industry l

In equation 3.28, the disaggregated row coefficients are summed to form the aggregate coefficients.

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28. This procedure assumes that the region's and the Nation's disaggregated industry-specific earnings-to-output ratios are the same. This assumption is consistent with the household-row estimation methodology presented above. This procedure could be extended to estimate a regional transactions matrix (that is, $X_{ij}^r = a_{ij}^r \; X_j^r$). However, this matrix (X_{ij}^r) does not identify whether inputs are produced locally or imported.

RIMS II Regional Direct Coefficients

RIMS II is based on a flexible national I-O model that can be used to construct regional I-O coefficients defined on an industry-by-industry or an industry-by-commodity basis. Regardless of the type of regional I-O model needed, RIMS II regional direct coefficients are estimated by using a disaggregated location technique, which, compared with aggregate LQ techniques, better takes into account the differences between the Nation's and a region's output mix. In RIMS II, earnings-based LQ's are used for industries that sell predominately to intermediate demand, while personal income-based LQ's are used for industries that sell predominately to final demand. The use of personal income-based LQ's in service-type industries is intended to account for all sources of output demand in these industries. Furthermore, when it is appropriate to treat endogenously the household sector, RIMS II estimates regional household-row and household-column coefficients based on national I-O household payment and expenditure coefficients. Finally, while RIMS II regional direct coefficients are estimated at the 496-industry level, they can be aggregated to a less detailed industry level if appropriate for a particular application.

In summary, two additional observations on RIMS II should be made. First, RIMS II estimates a regional direct-coefficient matrix rather than a regional transactions matrix. Thus, RIMS II does not indicate the dollar levels of industry-specific output or final demand. However, for use in impact analysis, the RIMS II-estimated coefficient matrix is sufficient. In addition, estimating the coefficient matrix without first estimating the transactions matrix reduces the data requirements of RIMS II. Furthermore, as indicated in chapter 5 of this monograph, when multipliers from RIMS II and those from survey-based transactions tables are compared, multiplier differences are small in many industries, even though RIMS II estimates are based on considerably less data. Second, while RIMS II regional direct coefficients are based on purely nonsurvey techniques, survey data, if available, can be used to further adjust the RIMS II coefficients. For example, in impact analysis, survey data are often available on the industry-specific initial impacts to be studied. Therefore, RIMS II can employ as much survey data as it is cost effective to gather for analyzing a given initial impact.

Chapter 4

ESTIMATION OF REGIONAL MULTIPLIERS

The I-O accounting system, detailed in chapter 3 of this monograph, can be expressed in the following simplifying equation:

$$X^r - A^r X^r = Y^r \tag{4.1}$$

where:

X^r = a column vector of regional gross output

A^r = a matrix of regional direct-purchase coefficients

Y^r = a column vector of regional final demand

Equation 4.1 states that total regional output (X^r) minus regional interindustry transactions ($A^r X^r$) is equal to final demand (Y^r); Y^r includes local final demand and net final demand by other regions. When households are treated exogenously, local final demand includes sales by the industries in region r to households in the form of personal consumption, private investment, and government purchases in region r; when households are treated endogenously (as discussed in chapter 3) by expanding the A^r matrix to include a household row and a household column, local final demand includes sales only to private investment and government in region r. The other component of Y^r, net final demand by other regions, includes exports (which are assigned a positive value) and inports (which are assigned a negative value). Therefore, Y^r will increase if any of the following items increase: household personal-consumption expenditures (when households are exogenous), regional private investment, regional government expenditures, and regional exports. Y^r will increase also if regional imports decrease. The regional purchase-coefficient matrix (A^r), while useful by itself in certain types of impact analyses, does not indicate the total effects on regional output and earnings caused by exogenous changes in economic activity. In order to show these total effects, A^r can be used to form a regional multiplier matrix.

Multipliers can be estimated by the Leontief inversion of A^r or by shortcut techniques that do not use the full A^r matrix. The most straightforward approach is the Leontief inversion. However, the cost of constructing survey-based A^r matrices, and the inaccuracies often associated with previously estimated nonsurvey A^r matrices, have led to several efforts to estimate multipliers using shortcut techniques. These shortcut techniques can be used to estimate column-total multipliers and earnings multipliers, although they cannot be used to estimate a full multiplier matrix. This chapter describes both the Leontief inversion and the shortcut techniques for estimating multipliers. In addition, techniques for estimating earnings multipliers are discussed. The chapter concludes with a discussion of RIMS II regional multipliers.

Leontief Inversion RIMS II Approach

Based on the RIMS II techniques for estimating A^r, the inversion RIMS II approach estimates the multiplier matrix by Leontief inversion. This can be accomplished by, first, rewriting equation 4.1 as:

$$(I - A^r)\ X^r = Y^r \tag{4.2}$$

Second, premultiplying both sides of equation 4.2 by $(I - A^r)^{-1}$ yields:

$$X^r = (I - A^r)^{-1}\ Y^r \tag{4.3}$$

or

$$X^r = B^r\ Y^r \tag{4.4}$$

where:

$$B^r = (I - A^r)^{-1}$$

B^r is often referred to as the regional Leontief inverse matrix. In equations 4.3 and 4.4, gross output is expressed as a function of final demand. The gross output effects of changes in final demand can be estimated by the regional total multiplier matrix (B^r). This estimation can be represented as follows:

$$\Delta X^r = B^r\ \Delta Y^r \tag{4.5}$$

For a given change in final demand (ΔY^r), the multiplier matrix (B^r) shows the total effects on output (ΔX^r) for each of the region's industries.

RIMS II multipliers, estimated by $(I - A^r)^{-1}$, can be based on either an exogenous household sector or an endogenous household sector. As discussed by Richardson (1972), Schaffer, et al. (1976), and others, if the household sector is not included in A^r, then B^r shows the direct and indirect effects on regional output, but if the household row and column coefficients are included in A^r, B^r shows, in addition to the direct and indirect effects, the effects on regional output induced by households spending the additional income that arises because of the final demand change. If A^r and, therefore, B^r are expanded to include both a household row and column, then values in the multiplier matrix are larger than those from the same matrix but without an endogenous household row and column. If a regional household row is included in A^r, but the household-column coefficents are set equal to zero, then households are exogenous with respect to the multiplier calculation, and the household row of B^r shows only the direct and indirect

effects on regional household earnings. Thus, if the household column is a zero vector, the effects of households' spending on regional output and earnings are not included in the multiplier calculation. However, when the actual household-column coefficients are included in A^r, as discussed by Richardson (1972) and others, the household row of B^r shows the direct, indirect, and consumer-induced earnings impacts per unit of final-demand change. In the latter case, households are endogenous.

It is important to recognize that inversion RIMS II multipliers can be estimated with or without an endogenous household. However, since a major goal of the research presented in this monograph is to show that RIMS II multipliers are often a reasonable alternative to the multipliers derived from more costly regional survey-based I-O tables, an endogenous household sector was used to derive the RIMS II multipliers for the accuracy comparisons in chapter 5 and the sample applications in chapter 6, because the multipliers derived from regional survey-based tables most often have been defined with an endogenous household sector. As indicated by Miernyk (1967) and Batey and Madden (1980), further research on how to treat the household sector (and other sectors that can be viewed as either endogenous or exogenous) would be useful.

Shortcut Techniques

The various techniques for estimating regional multipliers without a full regional direct-purchase coefficient table are based on an empirical and conceptual relationship between the column-total direct-multiplier component and the column-total multiplier. Specifically, Drake (1976) and Burford and Katz (1977) argue that column-total multipliers can be approximated by equations with only the column sums of A^r and certain region-specific factors as explanatory variables. These shortcut techniques can be classified into three groups based on the type of explanatory variables used: the original RIMS proxy variable approach, the original Burford-Katz formula, and the alpha regression RIMS II approach. Shortcut techniques, like the Leontief inversion technique, can be used to estimate regional multipliers specified with or without an endogenous household sector. However, for the reasons mentioned above, the original RIMS and alpha regression RIMS II shortcut techniques presented in this chapter are based on an endogenous household sector.

Original RIMS approach

Drake (1974) showed that, under certain conditions, the relationship between the direct and indirect-induced components of the total multiplier can be specified by the following equation:

$$d^r_{\cdot j} = a^r_{\cdot j}\left(\frac{1}{1-\bar{a}^r} - 1\right) \tag{4.6}$$

where:

$d^r_{\cdot j}$ = the total indirect-induced-multiplier component for column j

$a^r_{\cdot j}$ = the total direct-multiplier component for column j

$\bar{a}^r$ = the average total direct-multiplier components for all j columns

In equation 4.6 and elsewhere in this monograph, the dot (.) in place of a subscript refers to summing across that subscript. The column-total multiplier ($b^r_{.j}$) is defined as the sum of the initial-impact component (1.0), the total direct component ($a^r_{.j}$), and the total indirect-induced component ($d^r_{.j}$). Drake called the expression in parentheses the regional interdependency coefficient (alpha).

Since $a^r_{.j}$ is not known for regions without I-O models, Drake (1976) used regression analysis to search for suitable proxy variables for alpha in order to estimate $d^r_{.j}$. The general form of Drake's equation can be expressed as:

$$d^r_{.j} = \alpha\,(a^r_j;\ F^r_1,\ F^r_2, \ldots . F^r_n) \tag{4.7}$$

where:

$F^r_1, F^r_2, \ldots . F^r_n$ = a series of region-specific proxy variables for alpha

Based on a sample of 503 observations from 14 regional survey-based I-O tables, Drake estimated equation 4.8, which can be referred to as the original RIMS technique for estimating the indirect-induced-multiplier component:1/

$$\log d^r_{.j} = \underset{(32)}{1.507} - \underset{(9)}{1.818}\ P^r_1 - \underset{(4)}{0.308}\ P^r_2 + \underset{(32)}{0.169}\ \log S^r_2 + \underset{(40)}{1.030}\ \log a^r_{.j} \tag{4.8}$$

$$\bar{R}^2 = .868$$

where:

P^r_1 = agriculture's proportion of the region's total nongovernment earnings

P^r_2 = manufacturing's proportion of the region's total nongovernment earnings

S^r_2 = the region's nongovernment earnings as a proportion of the Nation's nongovernment earnings

The positive coefficient for $a^r_{.j}$ in this equation is consistent with the observation that the larger the direct-multiplier component, the larger the total multiplier. The positive coefficient for the S^r_2 is consistent with the expectation that larger areas are

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1. The t-statistics for the equations in this chapter are shown in parentheses under each coefficient.

more self-sufficient and, therefore, for a given $a^r_{.j}$, will have a larger total multiplier than will smaller regions. Drake did not discuss the significance of the signs for P^r_1 or P^r_2.2/

There are two possible problems associated with using equation 4.8 for estimating the indirect-induced-multiplier component. First, if the estimated coefficients are uniquely associated with the 14 sample regional tables, then the equation is inappropriate for use in other small-area impact studies. To explore this possibility, equation 4.8 was reestimated, using 228 additional observations from 3 more recent regional tables: Texas; Washington; and West Virginia.3/ The results of this analysis indicate that the coefficient changes for S^r_2 and P^r_1 were significant at the 1-percent level, and that P_1 was no longer a significant explanatory variable at the 1-percent level.4/ These findings raise questions about the universality of the original RIMS relationship (equation 4.8).

Second, an examination of the original 14 tables shows that major differences exist in their definitions and conventions, thus raising questions about the validity of the regression coefficients (notably P^r_1 and P^r_2) indicated in equation 4.8. 5/ For example, some tables use a value-added definition for the household row, while others use a wage-and-salary definition. In addition, two tables do not take into account the leakage effect of personal income taxes; in these tables, all labor income is assumed to be available for intraregional personal consumption expenditures.

In order to see if an alternative to the original RIMS equation could be estimated, based on these differences in table conventions, equation 4.8 was respecified, employing

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2. A possible explanation for these negative coefficients is that P^r_1 and P^r_2 are measures of the relative size of the basic sector of the economy, and, ceteris paribus, the larger the basic sector, the smaller the indirect and induced local service-sector impacts. If this is true, however, regional variables for other parts of the basic sector (for example, mining) perhaps should have been included in the equation.

3. The structure of these tables is described in appendix A.

4. In log form, the original RIMS equation is:

$$\underset{}{\log d^r_{.j}} = \underset{(26)}{1.068} - \underset{(8)}{0.048} \log P^r_1 - \underset{(3)}{0.047} \log P^r_2 + \underset{(31)}{0.166} \log S^r_2 + \underset{(40)}{1.058} \log a^r_{.j} \qquad \bar{R}^2 = .861$$

With additional observations from the three recent survey-based tables, the original RIMS equation is:

$$\log d^r_{.j} = \underset{(24)}{0.940} - \underset{(2)}{0.011} \log P^r_1 - \underset{(4)}{0.066} \log P^r_2 + \underset{(32)}{0.134} \log S^r_2 + \underset{(45)}{1.098} \log a^r_{.j} \qquad \bar{R}^2 = .833$$

5. However, Drake (1976) took into account the significantly different treatment of margin sectors among the survey-based tables.

dummy variables to reflect the different conventions. It was expected that tables with value-added household rows and tables that neglected the leakage of some income to taxes would have higher indirect-and-induced-multiplier components (because more income would be respent within the region) than other tables. In addition, the industrial-structure variables (P_1^r and P_2^r) in the original RIMS equation 4.8 were omitted, since the elasticities for these industrial-structure variables were relatively low in the original RIMS equation. The results of this reestimated RIMS equation are presented below in equation 4.9:

$$\log d^r_{\cdot j} = \underset{(38)}{1.049} + \underset{(34)}{.147} \log S_2 + \underset{(51)}{1.084} \log a^r_{\cdot j} + \underset{(11)}{.190}\ VA + \underset{(10)}{.269}\ TAX \qquad \bar{R}^2 = .908 \tag{4.9}$$

where:

VA = 1, if the household row is defined on a value-added basis; 0, otherwise

TAX = 1, if tax leakages are not taken into account; 0, otherwise

The positive and significant coefficients of the value-added household row and tax-leakage dummy variables indicate that these variables increase the size of multipliers, as hypothesized. In addition, the $\bar{R}^2$ for equation 4.9 is slightly higher than that for equation 4.8, indicating a somewhat better fit. Moreover, when equation 4.9 was estimated with the additional 228 observations from the 3 more recent survey-based tables, the coefficient changes were small compared to those in equation 4.8, indicating that the reestimated RIMS equation is more stable than the original RIMS equation.6/

Original Burford-Katz formula

Based on Drake (1974) and Burford and Hargrave (1974a and 1974b), Burford and Katz (1977) reexpressed equation 4.6 for the purpose of providing estimates of column-total multipliers. This reformulation is represented in equation 4.10:

$$b^r_{\cdot j} = 1.0 + \frac{a^r_{\cdot j}}{1 - \bar{a}^r} \tag{4.10}$$

where:

$b^r_{\cdot j}$ = the column-total multiplier for industry j

Burford and Katz offered this equation as a computationally simple alternative to other shortcut techniques for approximating multipliers. In addition, Burford and Katz

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6. With the additional observations from the three recent survey-based tables, the reestimated RIMS equation is:

$$\log d^r_{\cdot j} = \underset{(52)}{1.069} + \underset{(42)}{0.154} \log S^r_2 + \underset{(60)}{1.11} \log a^r_{\cdot j} + \underset{(14)}{.234}\ VA + \underset{(14)}{.254}\ TAX \qquad \bar{R}^2 = .900$$

indicate that the formula can be used with the household-payments-row coefficient ($a^r_{n+1,j}$) either included or excluded. Thus, the column-total multipliers specified by equation 4.10 can include either the direct and indirect effects, or the direct, indirect, and induced effects, of final-demand changes.

Two types of empirical tests on the original Burford-Katz formula have been performed. First, comparing randomly generated I-O matrices with a Louisiana I-O matrix with the same coefficient-column sums, Burford and Katz found only slight differences among the randomly generated multipliers; even smaller differences were found between the means of the random multipliers and the actual multipliers. For the Louisiana table, this result indicates that individual direct coefficients play a minor role in determining multiplier size, relative to the role of the direct-coefficient-column sums.

A second type of empirical test was based on a comparison of multipliers from regional tables, with multipliers estimated by equation 4.10. For example, using six regional tables with households exogenous, Katz and Burford (1980) show that the original Burford-Katz formula produces estimates of column-total multipliers that, on average, are within 5 percent of the actual multipliers.7/ Both tests suggest that the original Burford-Katz approach can provide reasonable column-total-multiplier estimates based only on direct coefficient-column sums.

Alpha regression RIMS II approach

Synthesizing the original RIMS proxy variable regression and the original Burford-Katz approaches yields a third technique for estimating column-total multipliers: the alpha regression RIMS II approach. The term, alpha regression, is adopted, because this approach makes a regression estimate of alpha in equation 4.6. This approach is based on both the original Burford-Katz formula and the orginial RIMS technique in that the indirect-induced multiplier is expressed as a function of $a^r_{.j}$ and $\bar{a}^r$. However, this relationship is econometrically estimated (as in the original RIMS proxy variable techniques), rather than specified as an identity-like formula (as in the original Burford-Katz technique). In addition, unlike the original Burford-Katz formula, which can be used with the household sector either included or excluded for a^r, the alpha regression RIMS II column-total multipliers are specified exclusively with an endogenous household sector. Moreover, since the household row coefficient ($a^r_{n+1,j}$) is frequently the largest single coefficient in $a^r_{.j}$, and, therefore, the level of leakages from the household earnings is especially important, it is useful to include the household-coefficient-column sum ($a^r_{.,n+1}$) to account for the import, tax, and savings leakages from household earnings.

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7. A new formula (which, in addition to assuming that $a^r_{.j}$ and $\bar{a}^r$ are known, assumes detailed information on the directly affected industry's individual coefficients, that is, a^r_{ij}) averages less than 1 percent error with respect to the actual multipliers; see Katz and Burford (1980). As presented in chapter 5 of this monograph, the results, using the original Burford-Katz formula to calculate multipliers with an endogenous household sector, are not as favorable. See also the refined Katz-Burford formula developed in Katz and Burford (1981).

Using data from the 14 regional I-O tables employed in the original RIMS estimation, the following alpha regression equation was estimated:

$$\log d^r_{\cdot j} = \underset{(46)}{1.601} + \underset{(18)}{1.150} \log \bar{a}^r + \underset{(43)}{1.091} \log a^r_{\cdot,n+1} + \underset{(52)}{1.062} \log a^r_{\cdot j} \qquad (4.11)$$

$$\bar{R}^2 = .925$$

where:

$a^r_{\cdot,n+1}$ = the sum of the regional household coefficient column

When compared to equations 4.8 and 4.9, the results of the alpha regression RIMS II equation appear clearly superior. The t statistics for all the variables are highly significant and somewhat larger than those of the other equations. Furthermore, when the additional observations from the more recent survey-based tables were used to estimate equation 4.11, the coefficient changes were small relative to those in the original RIMS equation.8/ In addition, the $\bar{R}^2$ is higher than those in the original RIMS and reestimated RIMS equations (4.8 and 4.9, respectively).

A concluding note on shortcut approaches

The three shortcut approaches described above were developed to avoid the difficulties of estimating the full regional coefficient-purchase matrix. However, two significant problems are associated with each of these techniques. First, the shortcut techniques have been developed from data derived from existing survey-based tables for regions which may not be representative of all regions. For example, the analysis presented above suggests an instability in regression coefficients when additional observations are employed. Furthermore, while the original RIMS approach and the alpha regression RIMS II approach explain much of the variation in $d^r_{\cdot j}$ based on a known $a^r_{\cdot j}$, multiplier estimates may be much less accurate when $a^r_{\cdot j}$ must be estimated. Similarly, tests of the original Burford-Katz formula are based on known $a^r_{\cdot j}$'s and $\bar{a}^r$'s; when these variables must be estimated, the formula's accuracy may decrease.9/

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8. With the additional data from the recent tables, the alpha regression equation is:

$$\log d^r_{\cdot j} = \underset{(46)}{1.600} + \underset{(20)}{1.041} \log \bar{a}^r + \underset{(53)}{1.123} \log a^r_{\cdot,n+1} + \underset{(65)}{1.066} \log a^r_{\cdot j}$$

$$\bar{R}^2 = .931$$

9. Katz and Burford (1980) advocate the use of survey and administrative-record data for estimating $a^r_{\cdot j}$ and $\bar{a}^r$. Thus, while fewer data are required for constructing these variables than constructing the full A^r matrix, data-gathering costs can still be high in many regions. In this respect, the original Burford-Katz formula is similar to the RAS technique. One solution to this problem would be to use the RIMS II technique for estimating $a^r_{\cdot j}$, and $\bar{a}^r$, and the original Burford-Katz formula for estimating total multipliers. However, the results presented in chapter 5 of this monograph indicate the superiority of the RIMS II approaches in estimating multipliers based on RIMS II estimates of $a^r_{\cdot j}$ and $\bar{a}^r$.

Second, the shortcut approaches do not estimate the full multiplier matrix (B^r), but only the column-total multipliers ($b^r_{.j}$). Thus, the often important industrial distribution of impacts cannot be seen. In this respect, the shortcut multipliers are similar to (although more industrially detailed than) the total multipliers produced by economic-base methodologies.

Earnings Multipliers

Up to this point, various techniques for estimating I-O column-total multipliers have been described. However, total multipliers are often not the relevant multipliers used in impact analysis. Earnings multipliers, which show the effects of regional final-demand changes on regional earnings, are often more appropriate. This section first describes the estimation of the earnings multiplier from the Leontief inverse matrix. A discussion of alternative formulas for calculating earnings multipliers by various short-cut techniques follows.

Earnings multipliers--Leontief inversion

In the Leontief inverse matrix (B^r), the earnings multiplier for a final-demand change in industry j is the household-row element of column j. The column-total multipliers of the multiplier matrix are represented in the following equation as being composed of two parts:

$$b^r_{.j} = \left(\sum_{i=1}^{n} b^r_{ij} \right) + b^r_{n+1,j} \tag{4.12}$$

where:

$b^r_{.j}$ = the column-total multiplier for industry j

b^r_{ij} = the i^{th} row multiplier in the j^{th} column

$b^r_{n+1,j}$ = the $n+1^{th}$ row (the household row) multiplier in the j^{th} column

The first term on the right side of this equation refers to the total-output multiplier, which is equal to the sum of the i industry-specific-output multipliers (b^r_{ij}). The second term on the right is the earnings multiplier.

The multiplier matrix also permits the estimation of household-earnings multipliers for individual-row industries for a given column industry's final-demand change. These multipliers can be estimated by multiplying the individual row-industry multiplier (b^r_{ij}) by the ratio of earnings to output in that industry ($a^r_{n+1,i}$). The sum of these i industry-specific earnings multipliers also equals the total-earnings multiplier ($b^r_{n+1,j}$) for a given column j. This is expressed in equation 4.13:

$$b^r_{n+1,j} = \sum_{i=1}^{n+1} b^r_{ij} \; a^r_{n+1,i} \tag{4.13}$$

where:

$b^r_{ij} \ a^r_{n+1,i}$ = the earnings multiplier for industry i given a final-demand change in industry j

Earnings multipliers--shortcut approaches

In addition to showing how industry-specific earnings multipliers can be summed to the total-earnings multiplier, equation 4.13 is the basis for alternative formulas for calculating a household-earnings multiplier when a shortcut technique is used to estimate the column-total multiplier ($b^r_{.j}$). Earnings-multiplier formulas are necessary since the shortcut techniques do not estimate the full-multiplier matrix (b^r_{ij}), but rather only its column sums ($b^r_{.j}$). The shortcut techniques, by themselves, provide no information about the relative size of the two parts of the column-total multiplier shown in equation 4.12.

The alternative earnings formulas can be derived by expressing equation 4.13 as:

$$b^r_{n+1,j} = b^r_{jj} \ a^r_{n+1,j} + \sum_{i=1}^{n+1} b^r_{ij} \ a^r_{n+1,i} \tag{4.14}$$

The first term on the right side of equation 4.14 represents that part of the earnings multiplier that occurs in the initially affected industry itself. The coefficient b^r_{jj} is the diagonal element of the j^{th} column in the multiplier matrix, and the coefficient $a^r_{n+1,j}$ is the household-row coefficient from the j^{th} column of the direct-coefficient matrix. The fact that the diagonal of the multiplier matrix is always greater than, or equal to, 1.0 can be used to express equation 4.14 as:

$$b^r_{n+1,j} = a^r_{n+1,j} + (b^r_{jj} - 1) \ a^r_{n+1,j} + \sum_{\substack{i=1 \\ i \neq j}}^{n+1} b^r_{ij} \ a^r_{n+1,i} \tag{4.15}$$

or

$$b^r_{n+1,j} = a^r_{n+1,j} + \sum_{i=1}^{n+1} b^{r'}_{ij} \ a^r_{n+1,i} \tag{4.16}$$

where:

$b^{r'}_{ij} = b^r_{ij}$ if $i \neq j$

$b^{r'}_{ij} = b^r_{ij} - 1$ if $i = j$

Equation 4.16 indicates that the earnings multiplier for industry j is composed of two parts: the direct-earnings effect in industry j, and the sum of the additional earnings effects in all industries. Moreover, since the shortcut techniques make estimates of $a^r_{n+1,j}$ in estimating $a^r_{.j}$ (the sum of the direct coefficients in column j), equation 4.16 can be used to generate earnings-multiplier formulas based on the relationship between $b^{r'}_{ij}$ and $a^r_{n+1,i}$.

Since $b^{r'}_{ij}$ is not estimated by the shortcut techniques for any particular column j, the original formula 10/ for calculating the total-earnings multiplier is based on the simplifying assumption that $a^r_{n+1,i}$ is constant across industries, and equal to the average of the direct household coefficients. Under this assumption, equation 4.16 becomes:

$$b^r_{n+1,j} = a^r_{n+1,j} + \bar{a}_{n+1} \sum_{i=1}^{n+1} b^{r'}_{ij} \tag{4.17}$$

where:

$\bar{a}_{n+1}$ = the average $a^r_{n+1,i}$ over the i industries

Furthermore, since from the conditions of equation 4.16,

$$b^r_{.j} = \left(\sum_{i=1}^{n+1} b^{r'}_{ij} \right) + 1 \tag{4.18}$$

the j^{th} column's earnings multiplier can be expressed as:

$$b^r_{n+1,j} = a^r_{n+1,j} + \bar{a}_{n+1} \quad (b^r_{.j} - 1) \tag{4.19}$$

As indicated in equation 4.19 (the original formula), the earnings multiplier is expressed as a function of the direct-earnings effect ($a^r_{n+1,j}$), the average direct-earnings effect ($\bar{a}_{n+1}$), and the column-total multiplier ($b^r_{.j}$).

An alternative earnings-multiplier formula, which includes the same variables as equation 4.19, also can be derived. In order to see how this alternative formula might be derived, equation 4.16 can rewritten as:

$$b^r_{n+1,j} = a^r_{n+1,j} + b^{r'}_{n+1,j} \; a^r_{n+1,n+1} + \sum_{i=1}^{n} b^{r'}_{i,j} \; a^r_{n+1,i} \tag{4.20}$$

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10. The term, original formula, is adopted here because it was employed in the original RIMS as described in U.S. Water Resources Council (1977). The original formula is also equivalent to one described by Burford and Katz (1977 and 1978a).

By writing the $(n+1)^{th}$ row outside the summation sign, a potential weakness of the original formula can be readily seen. Since $a^r_{n+1,n+1}$ (which represents the expenditures of households, paid directly to households) is always a small coefficient relative to $\bar{a}_{n+1}$, the use of the significantly larger $\bar{a}_{n+1}$ as an estimate of $a^r_{n+1,n+1}$ could lead to an overestimate of the earnings multiplier.11/

Given this overestimation bias, a modification of the original formula (equation 4.19) is appropriate. Instead of assuming that $a^r_{n+1,i}$ is constant for all i industries, the modified formula is based on the assumption that $a^r_{n+1,i}$ is constant only for the first n industries, and is equal to zero for the $(n+1)^{th}$ industry. This latter assumption is based on the recognition that the intrahousehold-expenditure coefficient ($a^r_{n+1,n+1}$) is generally small and, therefore, has a small relative effect on the total-earnings multiplier.

With $a^r_{n+1,n+1}$ equal to zero, and $a_{n+1,i}$ constant only for the first i industries, equation 4.20 becomes:

$$b^r_{n+1,j} = a^r_{n+1,j} + \bar{a}_{n+1} \sum_{i=1}^{n} b^{r'}_{ij} \qquad (4.21)$$

Since, by equations 4.12 and 4.18,

$$\sum_{i=1}^{n} b^{r'}_{ij} = b^r_{.j} - 1 - b^r_{n+1,j} \qquad (4.22)$$

then

$$b^r_{n+1,j} = a^r_{n+1,j} + \bar{a}_{n+1} \left(b^r_{.j} - 1 - b^r_{n+1,j}\right) \qquad (4.23)$$

Rearranging terms, equation 4.23 can be written as

$$b^r_{n+1,j} = \frac{a^r_{n+1,j} + \bar{a}_{n+1} \left(b^r_{.j} - 1\right)}{1 + \bar{a}_{n+1}} \qquad (4.24)$$

As can be seen from equation 4.24, this modified formula differs from the original formula (equation 4.19) in that the former is divided by the amount $1 + \bar{a}_{n+1}$. As a

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11. In national I-O tables and most regional tables, $a_{n+1,n+1}$ is less than 0.05, while $\bar{a}_{n+1}$ is above 0.30.

result, for a given column-total multiplier, earnings multipliers generated from this modified formula are less than those based on the original formula. For example, if $\bar{a}_{n+1}$ is equal to 0.3, then the multipliers generated from the modified formula are approximately 77 percent of the original formula's earnings multipliers.

RIMS II Regional Multipliers

RIMS II employs two alternative approaches for estimating column-total multipliers. For applications in which it is necessary to measure the impact of final-demand changes in numerous directly and indirectly affected industries, the inversion RIMS II approach (equation 4.4) is employed. This RIMS II approach estimates the full regional multiplier matrix (B^r).

For other applications that require measuring only the gross-output and earnings impacts associated with an industry-specific final-demand change, the shortcut alpha regression RIMS II approach (equation 4.11) can be employed. According to this RIMS II approach, only the column-total multiplier ($b^r_{\cdot j}$) is estimated. However, based on the alpha regression RIMS II column-total multiplier, the modified formula (equation 4.24) can be used to estimate the corresponding RIMS II earnings multiplier ($b^r_{n+1,j}$).

While the blending of these two approaches into RIMS II enhances the flexibility of the system, especially in terms of the range of applications for which it might be employed, the inversion RIMS II approach might be the more useful in impact studies for two reasons. First, the inversion RIMS II approach provides the industry-specific multipliers (b^r_{ij}'s) that are useful in many impact studies, while the alpha regression RIMS II approach does not. Second, in many instances, the time and computer costs required to calculate the alpha regression RIMS II and the inversion RIMS II multipliers may not differ significantly. For example, if the full A^r matrix must be calculated first in order to estimate $\bar{a}^r$ and $a^r_{\cdot,n+1}$ for use in the alpha regression RIMS II equation, then generating the full inversion RIMS II matrix is a relatively inexpensive computer calculation. However, it is important to recognize that there are instances where the alpha regression RIMS II approach may be more useful than the inversion RIMS II approach. If $\bar{a}^r$ and $a^r_{\cdot,n+1}$ are known (for example, from a previous regional I-O study where A^r was estimated), then the alpha regression RIMS II multiplier can be estimated based on these values and an estimate of $a^r_{\cdot j}$. Therefore, when there is no need to estimate A^r, the alpha regression approach is the more cost effective of the two RIMS II approaches.

Chapter 5

COMPARATIVE EVALUATION OF RIMS II PERFORMANCE

While chapters 3 and 4 describe various purely nonsurvey techniques for estimating regional I-O tables, chapter 5 presents a comparative evaluation of the RIMS II nonsurvey techniques with other nonsurvey techniques that are similar to RIMS and RIMS II. In order to do this, the first section of this chapter presents a summary description of the RIMS II approaches. The second section describes the general evaluation approach and the statistics used in comparing RIMS II and other nonsurvey techniques with survey-based I-O coefficients. The third and fourth sections present the results for column-total comparisons and full-multiplier-matrix comparisons, respectively. The fifth and last section summarizes the results of the comparative evaluation of RIMS II, and presents a discussion of the implications of the accuracy of RIMS II for its use in impact analysis.

Description of RIMS II

Table 5.1 lists the RIMS II techniques and various other nonsurvey techniques for estimating the regional I-O coefficients that are analyzed in this monograph. In estimating regional direct coefficients, RIMS II uses a disaggregated (i.e., based on 4-digit SIC data) mixed LQ approach. This is done for two reasons. First, as discussed in chapter 3 of this monograph, the use of disaggregated LQ's more fully takes into account the differences between the regional and national industrial mixes than do the more aggregated LQ's. Second, the use of mixed LQ's takes into account all sources of demand, rather than only the interindustry transactions accounted for by earnings-based LQ's.

For estimating column-total multipliers, RIMS II uses one of two approaches. The shortcut alpha regression RIMS II approach is used when only aggregate impacts for selected industries are desired. Among the various shortcut techniques examined in chapter 4, the alpha regression approach (equation 4.11) is superior to the original RIMS (equation 4.8) and the reestimated RIMS (equation 4.9) in terms of stability and explanatory power.

For more detailed applications, the RIMS II total multipliers are estimated by Leontief inversion of the regional direct-coefficients matrix. The inversion RIMS II approach provides an estimate of the full multiplier matrix and indicates the industry-specific effects of changes in final demand.

When the total multipliers are estimated by the alpha regression RIMS II approach, the RIMS II earnings multipliers are estimated by the modified formula (equation 4.24). This formula (as discussed in chapter 4) recognizes that the average direct household coefficient is not the appropriate earnings-to-output ratio for all row industries. When the full multiplier matrix is estimated by the inversion RIMS II approach, the earnings multipliers are the household-row coefficients of the multiplier matrix.

Overview of the Evaluation Methodology

This section focuses on a discussion of the methodology adopted for the evaluation of the accuracy of the RIMS II approaches, relative to other nonsurvey techniques. Jensen (1979) and others have pointed out the pitfalls of comparing survey and nonsurvey estimates of input-output coefficients. Such comparisons are particularly difficult, since significant measurement errors may be associated with both survey and nonsurvey estimates. More specifically, Jensen (1980) argues that the survey content of some survey-based tables may be too small to warrant viewing their results as accurate

Table 5.1.-Alternative Techniques for Estimation of Direct Coefficients, Total Multiplier, and Earnings Multiplier

Variable/technique	Equation number
Direct coefficients	
A 2-Digit earnings LQ's	3.15 with 3.14a where i=1,...,60
B 4-Digit earnings LQ's	3.15 with 3.14a where i=1,...,496
C* 4-Digit mixed LQ's	3.15 with 3.14a and 3.14b where i=1,...,496
Total multiplier	
2-Digit techniques	
D Inversion of direct coefficients from A	4.4
E Original RIMS with direct coefficients from A	4.8
F Reestimated RIMS with direct coefficients from C	4.9
4-Digit techniques	
G Original Burford-Katz Formula with direct coefficients from C	4.10
H* Alpha regression with direct coefficients from C	4.11
I* Inversion of direct coefficients from C	4.4
Earnings multiplier	
2-Digit techniques	
J Inversion of direct coefficients from A	4.12
K Original RIMS--total multipliers from E with the original earnings multiplier formula	4.19
L Original RIMS--total multipliers from E with the modified earnings multiplier formula	4.24
4-Digit techniques	
M Alpha regression--total multiplier from H with the original earnings multiplier formula	4.19
N* Alpha regression--total multiplier from H with the modified earnings formula	4.24
O* Inversion of direct coefficient from C	4.12

*Indicates RIMS II approaches.

measures of the true I-O relationships in a regional economy. Still, it is necessary to adopt some norm against which to compare the alternative techniques, and the survey-based tables are the most generally accepted basis for comparison.

The remainder of this chapter focuses on the estimates produced by the nonsurvey techniques relative to those of three recent survey-based tables: Texas (1972); Washington (1972); and West Virginia (1975). A general description of these tables, and of their respective sectoring designations, appears in appendix A. The choice of these tables reflects several considerations. First, they are relatively recent tables, and they use base years that are reasonably close to those used for the BEA national table. Second, they represent three distinct kinds of economies, in both size and industrial structure. Third, the tables are well documented so as to assure conformance with the national I-O table in terms of definitions and conventions. Fourth, they were estimated by experienced research personnel, thus lending credibility to the accuracy of the results.1/

Based on the three survey tables, an analysis is performed on the accuracy of three techniques for estimating the direct coefficients, six techniques for estimating the total multiplier (with households endogenous), and six techniques for estimating the total earnings multiplier. These estimation techniques are listed in table 5.1. They can be categorized into two broad groups: 2-digit techniques and 4-digit techniques.2/

The accuracy comparisons of alternative estimation techniques are conducted both at the column-total level and at the disaggregated cell-by-cell level. The aggregate comparisons are presented first, for two reasons. First, the shortcut multiplier techniques, as indicated in chapter 4, do not estimate the full multiplier matrix (b^r_{ij}), but rather only column total multipliers ($b^r_{.j}$). Therefore, only aggregate comparisons are possible for these shortcut techniques.

Second, the focus on aggregate accuracy comparisons may be more appropriate when the multipliers are intended for use in impact studies. For example, Jensen (1979) emphasizes the need for analyzing the holistic, rather than merely the partitive, accuracy of nonsurvey techniques. Jensen describes partitive accuracy as that which focuses primarily on cell-level comparisons of nonsurvey and survey results. He distinguishes this from holistic accuracy, which is more concerned with whether the application of a nonsurvey technique on the whole gives "reasonable" estimates of economic interrelationships. According to this latter approach, strict cell-by-cell accuracy comparisons are less important than considerations of the accuracy of the overall multipliers.

Numerous techniques have been employed in previous studies for the purpose of measuring accuracy in nonsurvey techniques. Percent error, Theil statistics, chi-square

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1. Although attempts were made to use a small-area (for example, an SMSA) table in the evaluation, none was found that met each of these four criteria.

2. For the purpose of a historical comparison with earlier BEA work, a strict formulation of the 2-digit LQ technique was not employed. Rather, a variation of the 2-digit LQ technique was used in estimating the multipliers analyzed in this chapter. According to this variation (part of the original RIMS technique), data on 4-digit industries are used to identify those that are not present in the study region. The remaining coefficients were then made more region-specific by the 2-digit LQ technique.

tests, as well as correlation and regression analysis, have been the most common approaches.3/ The analysis in this chapter primarily employs the statistic developed by Theil (1966).4/ An important reason for using the Theil statistic is that it combines both the absolute prediction error (which is the basis for the percent error and chi-square tests) and the degree of association between the actual and predicted values (which is the basis for correlation and regression analysis). In addition, unlike other tests, the Theil statistic does not suffer from the "small-cell" problems discussed by Morrison and Smith (1974) and others.

The Theil statistic (U) is based on the relative mean-square prediction error, and, as used in the accuracy comparisons presented in this chapter, is defined as:

$$U = \left(\frac{\sum (P_i - A_i)^2}{\sum A_i^2} \right)^{1/2} \qquad (5.1)$$

where:

P_i = the value predicted by the nonsurvey table

A_i = the actual value for the survey table

If the predicted and actual values are identical in all cases, then U equals zero; if the predicted and actual values are unequal in some cases, then U is not equal to zero. Furthermore, the larger the difference between P_i and A_i, the larger the value of U. For this reason, the statistic is often referred to as the Theil inequality coefficient. The lower bound of U is zero; the statistic has no finite upper bound. One of the important features of the Theil statistic is that U can be decomposed into three sources of prediction error. If U is not equal to zero, errors of central tendency (U^m), unequal variation (U^s), or incomplete covariation (U^c) may occur . The three sources of error are defined as proportions that sum to one. Theil (1961 and 1966) argues that if predictions are not perfectly accurate the desirable distribution of the inequality proportions is $U^m = U^s = 0$ and $U^c = 1$. Small proportions for U^m and U^s indicate that systematic errors are not large, while a large proportion for U^c indicates that individual cell-level errors predominate. The Theil statistic is especially useful when comparing alternative nonsurvey techniques. For example, in general the technique with the lowest U value would be the preferred technique, especially if this technique also had the lowest values for U^m and U^s and the highest value for U^c.

Another indication of the accuracy of nonsurvey techniques relative to that of the survey-based multipliers can be obtained from the chi-square statistic. For each column,

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3. For examples of the range of tests applied in analyzing the accuracy of nonsurvey techniques, see Schaffer and Chu (1969), Morrison and Smith (1974), and Stevens, et al. (1980).

4. The Theil statistic has been employed in regional I-O analysis by Stevens and Trainer (1980).

this statistic measures the degree of association between the nonsurvey multipliers and the survey multipliers, where the multipliers in each of the rows are expressed as proportions of the column-total multiplier. The actual form of the statistic is given in equation 5.2. 5/

$$\text{chi-square} = \sum_{i=1}^{n} \frac{\left(P_i - A_i\right)^2}{A_i} \tag{5.2}$$

where:

$$P_i = \frac{\hat{b}^r_{ij}}{\hat{b}^r_{\cdot j}}$$

$$A_i = \frac{b^r_{ij}}{b^r_{\cdot j}}$$

The circumflex ($\wedge$) refers to the nonsurvey multiplier matrix values. For a given column, if the nonsurvey and survey multipliers had the same proportional distribution of multipliers among affected row industries, P_i would equal A_i in all cases, and the value of the chi-square statistic would be zero. Alternatively, the greater the dissimilarity (in terms of the relative size of industry-specific multipliers for that column) between the nonsurvey and survey tables, the larger the statistic.

In addition to the Theil and chi-square statistics, Spearman-rank correlation statistics are useful in assessing the accuracy of the estimation techniques.6/ The Spearman-rank correlation coefficient (r_s) can be defined as follows:

$$r_s = 1 - \frac{6 \sum_{i=1}^{N} D_i^2}{N(N^2 - 1)} \tag{5.3}$$

where:

D_i = the difference between the size rankings of $\hat{b}^r_{ij}$ and b^r_{ij} in column j

N = the number of observations, that is, the number of rows in each column

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5. The use of the chi-square statistic as a summary statistic in this context is similar to the chi-square goodness-of-fit test, discussed by Wonnacott and Wonnacott (1977) and others.

6. For an example of the use of the Spearman statistic in I-O analysis, see Bezdek and Wendling (1976).

The Spearman-rank correlation measures the degree of association between two distributions of rankings; if the rankings were the same, the Spearman-rank correlation coefficient would equal one. In implementing this statistic, the multiplier values for the rows in each column are ranked from highest to lowest for both the survey and nonsurvey matrices. Spearman-rank correlation coefficients are then calculated for each column in each of the State matrices.

Column-Total-Level Accuracy Comparisons

The first three tables in this section present a summary of relevant error statistics associated with alternative techniques for estimating the direct coefficients, the total multiplier, and the earnings multiplier. These statistics have been calculated for three States at the column-total level. The statistics were based on 133 column observations for Texas, 50 column observations for Washington, and 41 column observations for West Virginia. The mean column values in these tables are the unweighted averages of the individual column values; the ratios of means are calculated as the mean nonsurvey value divided by the mean survey value.

Focusing first on the accuracy of the estimates of the direct coefficients, tables 5.2-5.4 indicate several patterns that are apparent across each of the States. First, all the statistics indicate appreciably larger errors associated with the 2-digit SIC earnings LQ's than with either of the 4-digit techniques. Furthermore, a consistent, although slight, increase in accuracy is also associated with the use of mixed LQ's employed in the RIMS II approach. Second, a substantially greater portion of the error (as indicated by the Theil statistic) is associated with central tendency in the case of the 2-digit LQ's, as opposed to the 4-digit LQ's. Slight improvement in this measure is also evident when comparing the 4-digit mixed LQ's employed in the RIMS II approach with those of the 4-digit earnings LQ's.

Turning to the consideration of the accuracy of the total multiplier results, similar conclusions are evident. With few exceptions, errors associated with the 2-digit techniques are consistently greater than those associated with the 4-digit techniques, and a large portion of the errors in the 2-digit techniques are attributable to errors in central tendency. Further, it should be noted that the alpha-regression RIMS II and the inversion RIMS II approaches generate total multiplier estimates that are quite similar.

The results of the total multiplier analysis also suggest several other findings regarding the accuracy of alternative nonsurvey techniques. First, of the 2-digit techniques, none is clearly superior in all cases. For example, the accuracy of the inversion 2-digit technique is relatively poor in Washington and relatively good in West Virginia. Furthermore, while the reestimated RIMS approach is superior to the original RIMS approach in Texas and West Virginia, it is inferior in Washington. Second, of the 4-digit techniques, both the alpha regression and the inversion RIMS II approaches consistently outperform the original Burford-Katz formula, as measured by the Theil statistics and mean multiplier ratios.7/ For example, the Theil statistic for central

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7. For the original Burford-Katz approach these results are not as favorable as those for multipliers that were calculated without an endogenous household row and column; see Katz and Burford (1980) for these results with households exogenous. A probable cause for the relatively poor results generated by the original Burford-Katz formula, when households are endogenous, is that the large household-row coefficients (especially the value-added coefficients in Washington) violate the randomness assumptions used in deriving the formula; Jensen (1978a and 1978b) and Burford and Katz (1978b) contain

Table 5.2.-Distribution of Theil Statistics and Ratios (Nonsurvey/Survey) at the Column-Total Level

Texas

Variable/technique	Theil statistic				Mean		Ratio of mean
	U	U^m	U^s	U^c	Nonsurvey	Survey	
Direct coefficient							
2-Digit earnings LQ's	0.3210	0.3435	0.0048	0.6517	0.7366	0.6176	1.1927
4-Digit earnings LQ's	.2217	.1320	.0290	.8390	.6685	.6176	1.0824
4-Digit mixed LQ's*	.2187	.1217	.0327	.8456	.6659	.6176	1.0782
Total multiplier							
Inversion with 2-digit earnings LQ's	.2944	.5925	.0020	.4055	3.4467	2.8036	1.2294
Original RIMS with 2-digit earnings LQ's	.2923	.6094	.0005	.3901	3.4509	2.8036	1.2309
Reestimated RIMS with 2-digit LQ's	.1770	.0848	.0307	.8844	2.9490	2.8036	1.0519
Original Burford-Katz with 4-digit mixed LQ's	.1566	.1813	.0483	.7705	2.9928	2.8036	1.0675
Alpha regression with 4-digit mixed LQ's*	.1435	.0356	.0648	.8997	2.8804	2.8036	1.0274
Inversion with 4-digit mixed LQ's*	.1504	.1289	.0248	.8463	2.9569	2.8036	1.0547
Earnings multiplier							
Inversion with 2-digit earnings LQ's	.3078	.2405	.0123	.7472	.8191	.7074	1.1579
Original RIMS with 2-digit earnings LQ's							
Original formula	.6267	.7072	.0001	.2926	1.0974	.7074	1.5514
Modified formula	.3413	.2191	.0386	.7423	.8256	.7074	1.1671
Alpha regression with 4-digit mixed LQ's							
Original formula	.4019	.4621	.0026	.5353	.9095	.7074	1.2857
Modified formula*	.2717	.0132	.1051	.8817	.6843	.7074	.9674
Inversion with 4-digit mixed LQ's*	.2319	.0005	.0559	.9436	.7035	.7074	.9945

*Indicates RIMS II approaches.

Table 5.3.-Distribution of Theil Statistics and Ratios (Nonsurvey/Survey) at the Column-Total Level

Washington

Variable/technique	Theil statistic				Mean		Ratio of means
	U	U^m	U^s	U^c	Nonsurvey	Survey	
Direct coefficient							
2-Digit earnings LQ's	0.2102	0.3741	0.0260	0.5999	0.8490	0.7504	1.1314
4-Digit earnings LQ's	.1461	.1086	.0116	.8798	.7873	.7504	1.0492
4-Digit mixed LQ's*	.1408	.0503	.0212	.9285	.7746	.7504	1.0322
Total multiplier							
Inversion with 2-digit earnings LQ's	.3410	.7676	.0117	.2207	3.9715	3.0502	1.3021
Original RIMS with 2-digit earnings LQ's	.1684	.4824	.0254	.4921	3.4108	3.0502	1.1182
Reestimated RIMS with 2-digit earnings LQ's	.1802	.5376	.0117	.4507	3.4604	3.0502	1.1345
Original Burford-Katz with 4-digit mixed LQ's	.4688	.9159	.0129	.0712	4.4373	3.0502	1.4548
Alpha regression with 4-digit mixed LQ's*	.1148	.2375	.0903	.6722	2.8776	3.0502	.9434
Inversion with 4-digit mixed LQ's*	.1107	.0711	.0082	.9207	3.1412	3.0502	1.0298
Value added multiplier							
Inversion with 2-digit earnings LQ's	.2535	.4085	.0048	.5867	1.3751	1.1794	1.1660
Original RIMS with 2-digit earnings LQ's							
Original formula	.5647	.7907	.0078	.2015	1.7861	1.1794	1.5145
Modified formula	.2101	.0184	.0484	.9332	1.1449	1.1794	.9708
Alpha regression with 4-digit mixed LQ's							
Original formula	.3441	.5442	.0184	.4374	1.4861	1.1794	1.2601
Modified formula*	.2660	.4976	.0330	.4694	.9527	1.1794	.8078
Inversion with 4-digit mixed LQ's*	.1709	.1860	.0320	.7820	1.0903	1.1794	.9245

*Indicates RIMS II approaches.

Table 5.4.-Distribution of Theil Statistics and Ratios (Nonsurvey/Survey) at the Column-Total Level

West Virginia

Variable technique	Theil statistic				Mean		Ratios of means
	U	U^m	U^s	U^c	Nonsurvey	Survey	
Direct coefficient							
2-Digit earnings LQ's	0.3739	0.2116	0.0006	0.7879	0.5880	0.4990	1.1784
4-Digit earnings LQ's	.3060	.0641	.0101	.9259	.5391	.4990	1.0804
4-Digit mixed LQ's*	.3029	.0575	.0125	.9300	.5366	1.0754	1.0754
Total multiplier							
Inversion with 2-digit LQ's	.2789	.4601	.0134	.5265	2.3161	1.9448	1.1909
Original RIMS with 2-digit LQ's	.4106	.7262	.0173	.2564	2.6316	1.9448	1.3532
Reestimated RIMS with 2-digit LQ's	.2931	.5568	.0092	.4340	2.3740	1.9448	1.2207
Original Burford-Katz with 4-digit mixed LQ's*	.1946	.3111	.0004	.6884	2.1579	1.9448	1.1096
Alpha regression with 4-digit mixed LQ's*	.1728	.1608	.0030	.8362	2.0808	1.9448	1.0699
Inversion with 4-digit mixed LQ's*	.1821	.1526	.0005	.8469	2.0845	1.9448	1.0918
Earnings multiplier							
Inversion with 2-digit earnings LQ's	.3542	.2781	.0007	.7212	.5700	.4749	1.2003
Original RIMS with 2-digit earnings LQ's							
Original formula	.8650	.6510	.0056	.3434	.8304	.4749	1.7486
Modified formula	.5306	.3074	.0059	.6867	.6247	.4749	1.3155
Alpha regression with 4-digit mixed LQ's							
Original formula	.5679	.3626	.0	.6374	.6491	.4749	1.3669
Modified formula*	.4043	.0043	.0499	.9458	.4883	.4749	1.0283
Inversion with 4-digit mixed LQ's*	.2848	.1014	.0003	.8983	.5211	.4749	1.0973

*Indicates RIMS II approaches.

tendency (U^C) for the original Burford-Katz formula is significantly higher for each State than the Theil statistics for the RIMS II approaches.

The earnings-multiplier results shown in tables 5.2-5.4 also indicate the superiority of the 4-digit techniques over the 2-digit ones, and the superiority of the RIMS II approaches over the other nonsurvey techniques. In addition, the tables show that the accuracy of the modified formula for calculating earnings multipliers is better than that of the original formula. Finally, in all cases, the Theil statistics for the earnings multipliers are somewhat greater than those for the corresponding total multipliers. This result suggests that, for a given column, the nonsurvey techniques are generally less accurate in estimating a given row element (in this case, the household row) than in estimating the column total itself.

In summary, it is important to emphasize the significant accuracy improvements brought about by using the RIMS II 4-digit mixed LQ's when compared with the 2-digit earnings LQ's, as indicated in tables 5.2-5.4. For example, with respect to the survey total multipliers for all three States, the average overestimation associated with the inversion of the 2-digit direct coefficient matrix is 24 percent.8/ For the inversion RIMS II approach, the corresponding overestimation is only 5.5 percent. Therefore, by using 4-digit SIC mixed LQ's, and thereby taking into account the disaggregated regional industrial structure, the accuracy of the purely nonsurvey LQ technique is significantly improved.

In order to further evaluate the accuracy of the RIMS II, it is useful to consider the distribution of column-total-multiplier ratios for several nonsurvey techniques. Rather than presenting results for the entire range of techniques shown in tables 5.2-5.4, the focus here is on the accuracy of two 2-digit approaches (original RIMS and inversion) and the two 4-digit RIMS II approaches (alpha regression and inversion). Since a basic purpose of this research is to improve the existing multiplier approach, the original RIMS approach is included here to facilitate historical comparison. The choice is made even though the reestimated RIMS approach performs slightly better than its earlier counterpart. The inversion 2-digit approach is included to facilitate the comparison of the 4-digit inversion RIMS II approach. Appendix tables B1.1-B1.3 present the industry-specific column total multiplier ratios for each State from which the results in table 5.5 were derived.

As is readily evident from the results presented in table 5.5, a substantially larger proportion of ratios lie between .90 and 1.09 for the RIMS II approaches.9/ For

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preliminary discussions of this issue. Katz and Burford (1981) developed refinements to their original shortcut formula that explicitly take into account a correction factor for an endogenous household sector. The refined Katz-Burford approach for calculating earnings multipliers is similar to the modified formula for earnings multipliers, derived in chapter 4; based on that similarity, the refined Katz-Burford approach should be more accurate than the original formula. The original Burford-Katz formula is included in the analysis in this chapter in order to provide an additional historical comparison with the original RIMS approach, which was developed (as shown in chapter 4) from a similar conceptual basis.

8. This average is obtained by weighting the overestimation of the mean multiplier by the number of columns in each State. This result is consistent with (although somewhat lower than) the findings of Schaffer and Chu (1969) and Morrison and Smith (1974).

9. The mean ratio is calculated as the unweighted average of the individual column ratios.

Table 5.5.-Distribution of Ratios of Column-Total Multipliers (Nonsurvey/Survey)

State/technique	Ratio range										Mean Ratio
	Below .70	.70-.79	.80-.89	.90-.94	.95-.99	1.00-1.04	1.05-1.09	1.10-1.19	1.20-1.29	Over 1.29	
Texas											
Inversion 2-digit earnings LQ's	1	2	5	0	4	6	10	26	29	50	1.25
Original RIMS 2-digit earnings LQ's	1	1	5	2	1	8	7	30	30	48	1.26
Alpha regression 4-digit mixed LQ's*	2	4	10	17	17	19	25	20	11	8	1.04
Inversion 4-digit mixed LQ's*	2	1	7	14	20	14	24	28	11	12	1.07
Washington											
Inversion 2-digit earnings LQ's	0	1	0	0	1	2	0	6	16	24	1.32
Original RIMS 2-digit earnings LQ's	0	0	3	1	4	3	12	13	8	6	1.13
Alpha regression 4-digit mixed LQ's*	0	3	9	14	12	6	2	2	2	0	0.95
Inversion 4-digit mixed LQ's*	0	1	4	1	10	14	9	6	3	2	1.04
West Virginia											
Inversion 2-digit earnings LQ's	1	0	0	2	5	3	3	9	5	13	1.21
Original RIMS 2-digit earnings LQ's	0	1	0	0	0	1	2	7	6	24	1.38
Alpha regression 4-digit mixed LQ's*	1	0	3	6	5	3	4	9	4	6	1.09
Inversion 4-digit mixed LQ's*	1	0	3	7	3	3	8	5	5	6	1.09

*Indicates RIMS II approaches.

example, only 20 observations for the 2-digit inversion technique fall between ratios .90 and 1.09 in Texas, while 72 observations for the 4-digit inversion RIMS II approach fall into this range. As with the Theil statistics, the alpha regression RIMS II and the inversion RIMS II approaches have a similar ratio distribution. Finally, in terms of the overall accuracy of the RIMS II approaches for all three States, almost 60 percent of column-total multipliers are within 10 percent of the corresponding survey values.

A comparison of the distribution of individual column-earnings-multiplier ratios (value-added-multiplier ratios for Washington) shows results similar to those for the total multiplier ratios. The distribution of column-earnings-multiplier ratios for each of four approaches is presented in table 5.6. (Appendix tables B2.1-B2.3 present the industry-specific earnings-multiplier ratios for each State.) With the exception of the original RIMS in Washington, both RIMS II approaches are superior to their 2-digit alternatives in estimating the earnings multipliers. However, the range of the distribution of the earnings multipliers is greater than that of the total-multiplier ratios. For example, approximately 60 percent of the inversion RIMS II earnings-multiplier ratios are within 15 percent of the survey values, while 60 percent of RIMS II total-multiplier ratios are within 10 percent of the survey values.10/

Two of the results shown in table 5.6 should be discussed here more fully. First, in West Virginia, the high mean ratios for the RIMS II approaches primarily are due to a substantial overestimation of the earnings multiplier for the instruments industry. When this industry is deleted from the calculation, the mean ratio of the alpha regression RIMS II approach decreases from 1.15 to 1.08, and that of the inversion RIMS II decreases from 1.19 to 1.11. These large decreases show the sensitivity of this statistic to changes in a few extreme ratios, particularly in tables such as West Virginia's, which lists relatively few industries.

Second, table 5.6 indicates that the alpha regression RIMS II approach significantly underestimates a large number of the value-added multipliers in Washington. Since this approach is considerably more accurate in estimating the column-total multiplier, underestimating the value-added multipliers probably is due to the inadequacy of the shortcut modified formula. More specifically, since the modified formula works better in Texas and West Virginia (where the household row is defined on an earnings basis) than in Washington, the incompatibility of the value-added household-row definition and the modified formula might be viewed as a basic cause of the underestimation in Washington. However, since the earnings household-row definition is used in many RIMS II applications, this shortcoming may be less serious. Still, further research into this problem would be useful.

Interindustry-Level Accuracy Comparisons

As described in the previous sections, aggregate comparisons of various nonsurvey techniques indicate the relative superiority of the RIMS II approaches, as well as their overall accuracy, when compared with survey-based counterparts. Since the shortcut techniques estimate only the column-total multiplier, disaggregated accuracy comparisons are impossible for these techniques. However, the inversion techniques estimate the full multiplier matrix, thereby enabling additional interindustry accuracy comparisons (based on the difference between $\hat{b}^r_{ij}$ and b^r_{ij}) to be made. Therefore, the purpose of this section

10. The greater range in the earnings-multiplier-ratio distribution is also reflected in the higher Theil statistic for the earnings multiplier when compared with those for the total multiplier.

Table 5.6.-Distribution of Ratios of Column Earnings* Multipliers (Nonsurvey/Survey)

State/technique	Ratio range										Mean Ratio
	Below .75	.75-.84	.85-.89	.90-.94	.95-.99	1.00-1.04	1.05-1.09	1.10-1.14	1.15-1.24	Over 1.24	
Texas											
Inversion 2-digit earnings LQ's	10	5	3	5	5	4	7	13	24	57	1.23
Original RIMS 2-digit earnings LQ's modified formula	8	6	4	3	5	6	10	8	76	65	1.25
Alpha regression 4-digit mixed LQ's modified formula**	18	11	14	11	8	16	14	11	12	18	1.03
Inversion 4-digit mixed LQ's**	18	10	10	11	14	6	13	19	13	19	1.04
Washington											
Inversion 2-digit earnings LQ's	2	0	0	2	0	3	10	1	14	16	1.21
Original RIMS 2-digit earnings LQ's modified formula	4	2	1	7	10	7	6	4	2	7	1.01
Alpha regression 4-digit mixed LQ's modified formula**	9	23	6	7	0	2	0	0	1	2	.83
Inversion 4-digit mixed LQ's**	5	3	7	8	8	9	3	0	1	6	.95
West Virginia											
Inversion 2-digit earnings LQ's	1	3	1	7	2	1	2	2	6	16	1.32
Original RIMS 2-digit earnings LQ's modified formula	3	0	0	2	0	2	1	5	1	27	1.49
Alpha regression 4-digit mixed LQ's modified formula**	4	3	4	6	2	1	4	2	3	12	1.15
Inversion 4-digit mixed LQ's**	2	3	6	1	3	1	4	3	3	15	1.19

*Value added multipliers for Washington.
**Indicates RIMS II approaches.

is to determine how closely the inversion techniques (notably the inversion RIMS II approach) approximate their survey-based counterparts at the interindustry level.

In this section, accuracy comparisons are first made on the basis of the Theil statistic calculated for each column, with observations being individual row elements of a column in the multiplier matrix. Thus, in Texas, 133 Theil statistics (one for each column) are calculated, each with 51 observations (one for each row).11/ In addition, the chi-square results and the results of the Spearman rank correlation test are discussed in order to indicate the similarity of the survey and nonsurvey columns in the multiplier matrices. Finally, the accuracy of the inversion approach is analyzed, based on a comparison of the percent errors associated with the larger cells of the multiplier matrix and the percent errors associated with the smaller cells of the multiplier matrix.

Table 5.7 presents the Theil statistic results for the inversion 2-digit and inversion RIMS II approaches. These results show that the inversion RIMS II approach records almost five times the number of Theil statistics in the lowest two groups when compared with its 2-digit counterpart. Similarly, in each State, substantially larger numbers of Theil statistics can be found in the .30-and-over group for the 2-digit technique, as compared with RIMS II.

Table 5.8 presents the results of the decomposition of the Theil statistic for the two inversion techniques. As indicated above, if prediction errors were present, then the ideal distribution of U^m, U^s, and U^c would be 0, 0, and 1. The results for each of the States again show the relative superiority of the inversion RIMS II approach when compared with its 2-digit counterpart. Further, this RIMS II approach exhibits little error associated with central tendency (U^m). However, a somewhat greater divergence from the ideal values is evident for the other Theil statistic components.

In order to describe further the interindustry accuracy of RIMS II, chi-square statistics and Spearman-rank correlation coefficients were calculated. For all three States, the average chi-square for RIMS II was .27; the average chi-square statistic was 280 percent higher for the 2-digit technique, when compared with the inversion RIMS II approach.12/ The low chi-square statistics for RIMS II indicate that RIMS II multipliers and multipliers from survey-based tables have similar proportional distributions of multipliers among affected row industries. In addition, Spearman-rank correlation coefficients calculated for the RIMS II approach indicate little significant difference between the survey and RIMS II multipliers in the rank ordering of row elements in each column. For example, in Washington, the Spearman coefficients were all significant at the .001 level, and greater than .9 for 43 of 50 column-total multipliers; the average coefficient was .94. In this context, the high coefficients indicate that the RIMS II approach shows a rank distribution of row industry-specific effects that is indistinguishable from that of the survey table. The results of the Spearman tests are not presented here, however, since the Spearman statistic is only a rank-size test, and,

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11. For the analysis of aggregate multipliers in the previous section, one Theil statistic is calculated for each State. For example, in analyzing the column-total direct coefficients, there are 133 predicted and actual observations for calculating the Theil statistic in Texas.

12. Chi-square statistics for each column-multiplier comparison are presented in appendix tables B3.1-B3.3.

Table 5.7.-Distribution of Theil Statistic

State/technique	Theil statistic range							Average
	.0000-.0499	.0500-.0999	.1000-.1499	.1500-.1999	.2000-.2499	.2500-.2999	Over .2999	
Texas								
Inversion 2-digit earnings LQ's	0	5	27	22	27	20	32	0.2403
Inversion 4-digit mixed LQ's*	0	24	53	22	15	10	9	.1654
Washington								
Inversion 2-digit earnings LQ's	0	2	13	8	13	4	10	.2383
Inversion 4-digit mixed LQ's*	1	23	16	2	4	2	2	.1309
West Virginia								
Inversion 2-digit earnings LQ's	0	7	9	7	8	3	7	.1944
Inversion 4-digit mixed LQ's*	0	17	7	9	3	1	4	.1493

*Indicates RIMS II approach.

Table 5.8.-Decomposition of Theil Statistic

State/technique	Percentile range										Average
	.01-.09	.10-.19	.20-.29	.30-.39	.40-.49	.50-.59	.60-.69	.70-.79	.80-.89	.90-1.00	
Texas											
Inversion 2-digit earnings LQ's											
U^m	56	54	23	0	0	0	0	0	0	0	0.12
U^s	38	23	28	13	10	8	8	5	0	0	.26
U^c	1	6	8	9	17	16	22	19	20	15	.63
Inversion 4-digit mixed LQ's*											
U^m	96	36	1	0	0	0	0	0	0	0	.06
U^s	56	22	19	13	6	8	6	3	0	0	.21
U^c	0	1	6	11	5	9	16	27	20	38	.73
Washington											
Inversion 2-digit earnings LQ's											
U^m	5	3	16	24	1	0	0	0	0	0	.28
U^s	6	6	11	11	7	5	3	1	0	0	.32
U^c	0	7	7	13	14	3	2	1	2	1	.39
Inversion 4-digit mixed LQ's*											
U^m	35	5	9	1	0	0	0	0	0	0	.09
U^s	16	8	4	7	8	2	0	2	3	0	.28
U^c	1	3	4	3	2	6	7	8	7	9	.63
West Virginia											
Inversion 2-digit earnings LQ's											
U^m	14	18	8	1	0	0	0	0	0	0	.13
U^s	15	8	7	4	4	2	1	0	0	0	.20
U^c	0	0	3	4	2	7	4	5	6	10	.67
Inversion 4-digit mixed LQ's*											
U^m	25	15	1	0	0	0	0	0	0	0	.09
U^s	16	9	5	5	2	2	1	1	0	0	.20
U^c	0	1	2	3	0	4	6	6	10	9	.71

*Indicates RIMS II approach.

therefore, weaker than the chi-square statistic, which evaluates the magnitude of multiplier errors.

Another indication of the accuracy of the Inversion RIMS II approach can be made by comparing the size of the RIMS II estimation error with the size of the survey table's multipliers.13/ For most multiplier columns, RIMS II makes relatively small percent errors for those cells that are a large percent of the survey table's total multiplier. This can be seen in the generally small percent errors for the earnings multipliers, which are always a large proportion of the column-total multiplier. Similarly, when relatively large percent errors occur, these errors are associated with the row elements that represent a small proportion of the column-total multiplier. For example, in Washington, individual multiplier-matrix cells that register errors larger than 100 percent represent row elements that are always less than 0.5 percent of the column-total multiplier. The inverse relationship between percent error and relative multiplier size is consistent with the Theil statistic and chi-square results, and is a further indication of the accuracy of the inversion RIMS II approach in estimating industry-specific multipliers.

RIMS II Accuracy and Impact Analysis

Among the alternative nonsurvey I-O techniques analyzed, the degree of accuracy of the RIMS II approaches is clearly higher than that of the other techniques. In addition, the RIMS II average multipliers overestimate the average survey multipliers by a small amount, and, for the majority of individual multiplier columns, RIMS II and survey multiplier differences are small. Furthermore, for a given multiplier matrix column, as shown by the chi-square and Spearman correlation results, RIMS II and survey multipliers have statistically similar row distributions of the column-total multiplier.

It is important to recognize that the RIMS II accuracy comparisons are based on results from survey tables, which, themselves, are estimates of the "true" I-O relationships in the economy.14/ Therefore, since measurement errors may be associated with both RIMS II and survey estimates, it is incorrect to ascribe the entire difference between RIMS II and survey multipliers to the RIMS II estimation error. The major implications of the accuracy comparisons for the use of RIMS II multipliers in impact analysis is that, on average and in a large number of cases, RIMS II and survey techniques provide similar estimates of the "true" regional I-O relationships.

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13. With multiplier size (defined as the survey table's row element divided by its column total multiplier) plotted on the y-axis, and with the percent error (defined as the RIMS II minus the survey table's row element divided by the survey table row element) plotted on the x-axis, this relationship, for each State, resembles a rectangular hyperbola.

14. Two sources of potential measurement error are associated with survey tables. First, since not all establishments are surveyed for data on industry-specific sales and purchases, the industry coefficients may refer only to the sampled establishments, whose activity may not be representative of the industry as a whole. For details on sampling procedures in constructing regional tables, see Miernyk, et al. (1970), Bourque and Conway (1977), and Loviscek, et al. (1979). Second, since industry-specific sales and purchases are seldom equal, in order to construct balanced regional transaction tables sales and purchase data must be reconciled by techniques that introduce either judgmental or stochastic error. For details on reconciliation techniques, see Gerking (1976), Jensen and McGurr (1976), Miernyk (1976), and Loviscek, et al. (1979).

Two additional observations on the accuracy of RIMS II for the purpose of impact analysis should be made. The first concerns the effects of multiplier errors on the size of impact errors. The second concerns the industry detail and base years used in accuracy comparisons, relative to the industry detail and time frames used in impact analysis. A discussion of these two points concludes this chapter.

Multiplier error and impact analysis

While RIMS II generally estimates multipliers that are similar to those in survey tables, for certain industries in each State RIMS II estimation errors may still be considered too large.15/ Conway (1977) and others have shown that the effect of a multiplier error on an estimated impact can be mitigated significantly by gathering primary data to detail the industry-specific final demand changes (ΔY_j^r) associated with the initial impact to be analyzed. Thus, when detailed industry-specific final demand data are available, the appropriate equation for impact analysis using RIMS II multipliers can be expressed as:

$$\Delta X_i^r = \sum_{j=1}^{n+1} b_{ij}^r \quad \Delta Y_j^r \tag{5.4}$$

where:

$j = 1,\ldots, n+1$

In equation 5.4, total estimated impact (ΔX_i^r) depends more on the overall accuracy of B^r and less on the accuracy of any one individual column of B^r.16/ Furthermore, since the final demand vector (ΔY^r) represents a survey-based estimate of initial impacts, which

15. In a benefit-cost study, Henry (1979) discusses the costs of multiplier-estimation errors with respect to impact analysis, and the benefits of gathering additional data for use in impact analysis. As indicated below, if time and money are available, gathering detailed data on industry-specific final demand changes may be especially cost effective. Mandeville and Jensen (1978) provide examples of disaggregating initial effects for use in regional I-O impact analysis. Miernyk, et al. (1970) use a similar concept in analyzing the impacts of a new firm or industry with a survey-based regional I-O model. Billings and Katz (1981) describe a similar technique, using an existing regional I-O model for estimating multipliers for an individual firm whose direct coefficients may deviate significantly from the average coefficients for the industry of which the firm is a part.

16. Often in I-O impact analysis, detailed industry-specific final demand data are not available. In this case, only the size of the final demand change for one industry (for example, industry j') is known, in which case the appropriate impact equation can be written as:

$$\Delta X_i^r = b_{ij}^r \quad \Delta Y_j^r \tag{5.4a}$$

where:

$j=j'$

are often a large proportion of total impacts, the effects of multiplier error on the total estimated impact can be small. Therefore, large gains in estimated impact accuracy can occur when survey data are first used to measure initial impacts; in that event, RIMS II multipliers are used to measure only additional or secondary impacts.

Industrial detail, base years, and impact analysis

The accuracy comparisons of RIMS II multipliers use the level of industry detail and the same base years as the survey I-O tables. This type of comparison may not present RIMS II in its best light for two reasons. First, RIMS II identifies considerably more individual industries than does the typical survey table. RIMS II estimates coefficients for 496 column industries, which then can be aggregated to the same level of industry detail as in the survey table. Therefore, if initial effects can be identified at a level of industry detail greater than that used in the survey table, RIMS II multipliers may be more useful in impact analysis than multipliers from survey tables.17/ For example, if the initial final demand change occurs for the output of the Scientific Instruments (SIC 3811) industry, a RIMS II multiplier can be calculated for this industry in any region. In the Washington table, the corresponding industry is Other Manufacturing, whose multiplier values are based on the aggregation of several 2-digit SIC industries--Instruments (SIC 38), Rubber (SIC 30), Leather (SIC 31), and Miscellaneous Manufacturing (SIC 39). Thus, in application, the RIMS II multiplier for Scientific Instruments may be more appropriate than is the Other Manufacturing multiplier from the Washington table.

Second, the survey I-O tables are estimated only for a fixed base year, while RIMS II multipliers can be estimated for any year. Conway (1980) shows that multipliers can be very sensitive to import-pattern shifts, and, therefore, regional I-O models should take into account these shifting regional import patterns. Since RIMS II multipliers can be estimated by taking into account recent import patterns, RIMS II multipliers may be more useful than those from survey tables, when the impact to be studied occurs in a year which is not the same as the base year of the survey table.18/

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17. The level of aggregation in the various regional survey I-O tables is based on the size of the regional industry and other important aspects of the regional economy. For example, in Washington, primary aluminum is separated from other primary metals. However, the level of aggregation that is appropriate for constructing a base-year transactions table may not be appropriate for the impact analysis. This is especially true for the regional impact analyses of either new industries or the expansion of existing small industries.

18. For any given quarter, the regional data base for RIMS II has a timelag of one year.

Chapter 6

APPLICATION OF RIMS II

RIMS II multipliers, like multipliers from other regional I-O models, are intended to show the total economic impacts of initial changes in regional economic activity. More specifically, RIMS II multipliers show the effects on regional total gross output, earnings, and employment of changes in regional final demands for imports or exports, new investments, and government expenditures.1/ The purpose of this chapter is to indicate in general terms several important aspects of the relationship between RIMS II multipliers and estimated impacts, and to show how RIMS II multipliers can be used to estimate the regional impacts of a specific Federal program--Local Public Works (LPW) construction expenditures for 1978.

RIMS II Multipliers and Impact Analysis

Any regional economic model makes certain assumptions about economic activity, and these assumptions affect the interpretation of the results estimated by the model.2/ The purpose of this section is to discuss five important aspects of the relationship between RIMS II multiplier specification and impact analysis. The discussion of RIMS II multipliers also applies to multipliers estimated by most regional I-O models. Furthermore, the discussion of the relationship between the specification of RIMS II and impact analysis is not intended as a complete discussion of all the potential problems which might arise when using RIMS II; rather it is intended to indicate the general types of problems that can be encountered, and, more importantly, how to incorporate solutions to these problems into the impact analysis.

First, the production function underlying RIMS II multipliers is the linear Leontief production function, which implies constant returns to scale and no substitution among inputs in producing each industry's output.3/ This assumption may not be valid in all

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1. Since RIMS II multipliers are often defined with an endogenous household sector, final demand in RIMS II can be categorized into three sectors: net export, investment, and government. However, the inversion RIMS II multipliers can be estimated with households exogenous, in which case final demand also includes the household personal-consumption (PCE) sector.

2. Glickman (1977) discusses the differing sets of assumptions for regional economic-base, regional I-O, and regional econometric models. For specific regional I-O model assumptions, see U.S. Water Resources Council (1977), U.S. Department of Agriculture (1978), and the studies referenced in chapter 2, footnote 2. For a more general discussion of the role of assumptions in models, see Ascher (1978).

3. When household payments are endogenous, the "fixed input coefficient" assumption means that a marginal change in final demand affects income based on the average industry-specific income-to-output ratio. That is, labor productivity does not change when output changes. When household consumption is endogenous, the "fixed input coefficient" assumption means that an additional dollar of income is spent in the same way as an average dollar of income. That is, the consumption function is linear. For a general discussion of this assumption, see Richardson (1972). For a discussion of techniques used to relax this assumption, see Miernyk, et al. (1967) and Batey and Madden (1980).

cases. However, Humphrey (1977), at the national level, and Conway (1977), at the regional level, have shown that changes in technical coefficients over 5-to-10-year time periods are small. Therefore, adopting the "fixed-input coefficient" assumption may be reasonable for many impact studies. Furthermore, in cases where adopting this assumption is not warranted, individual coefficients can be altered, based on more realistic assumptions. Often, this can be done simply by gathering data that identify the regional industry-specific final demand changes associated with the initial impact to be studied. As used in equation 5.3, these final demand data would describe the region's production relationships that are associated with the initial impact; the "fixed-input coefficient" assumption then would apply only in estimating additional or secondary effects.

Second, RIMS II multipliers are best used for analyzing the impacts of final demand changes that are small relative to the size of the impact region's economy. If the initial impact represents a small proportion of a regional industry's total output, then the impact will probably not be large enough to alter production technology, or change the regional source of inputs. However, this is not always the case. For example, a large construction project may exceed the output capacity of the region's construction-materials industries. Since import levels for such a project may be higher than average import levels for the region's economy, the multipliers for this project may be smaller than average. As in other cases, where the RIMS II multiplier specification is incompatible with the impact to be studied, the effects of this incompatibility can be mitigated by gathering survey data on project requirements.

A third consideration in the use of RIMS II multipliers is that impact regions should be delineated so as to conform to the supply areas of the inputs to the directly affected industries. Since RIMS II is a single-region, rather than an interregional, model, it is not capable of analyzing feedback effects from adjacent regions. By specifying the impact region as the supply area for inputs, these feedback effects are kept to a minimum. Therefore, in many RIMS II impact studies it is necessary that an impact region consist of several counties that are interrelated in terms of intercounty trade and commuting.

Fourth, RIMS II multipliers show the economic impacts of final demand changes on output and earnings in supplying industries. Thus, RIMS II multipliers, by themselves, do not show the effects of changes in regional economic structure. For example, in analyzing the regional impact of expanding a warehousing facility, the RIMS II multiplier for warehousing would show the regional effects of the increased output of industries that supply goods and services to the warehousing industry, but would not show the regional effects of additional manufacturing establishments that might locate near the expanded warehousing facility.[4] However, if the size of the final demand sales of these manufacturing establishments can be specified, and if appropriate RIMS II manufacturing multipliers are used, the additional manufacturing impacts can be estimated. In this case, the total regional impacts of the warehousing facility would equal the sum of the warehousing-only impacts and the manufacturing-only impacts.

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4. RIMS II multipliers, by themselves, only account for "backward-linkage" effects. "Forward-linkage" effects are common in less developed economies, where, for example, output changes induce labor inmigration, which, in turn, stimulates new housing and infrastructure construction. In general, "forward-linkage" effects require a case-by-case analysis. A discussion of when "forward-linkage" effects are likely to occur, and how to incorporate them into an impact study, can be found in U.S. Water Resources Council (1977).

Fifth, RIMS II multipliers estimate regional impacts, based on final demand changes. However, RIMS II does not indicate the existence or magnitude of any final demand substitution effects occuring within the regional economy as a whole. For example, if the increased expenditures associated with a construction project were financed by increased local taxes, there would ensue a positive regional impact, due to the positive final demand change in the investment sector, and a negative regional impact, due to the effect of increased personal taxes in reducing the household consumption of locally produced goods and services.5/ However, if the size of these substitution effects can be identified, positive and negative regional impacts can be estimated, using RIMS II multipliers, and the impacts can be summed to form net regional impacts.

RIMS II Estimated Impacts of LPW

RIMS II multipliers can be used to estimate the regional economic impacts of numerous public-sector policies. The purpose of this section is to indicate how these multipliers can be used to estimate the regional gross-output and earnings effects of the Federal LPW program. First, the scope and objectives of the LPW program are described briefly; RIMS II multipliers for selected LPW construction projects in three SMSA's are then presented, followed by a discussion of the metropolitan-area impacts estimated by the RIMS II multipliers. The section concludes with several observations on the scope of the LPW economic impacts estimated by RIMS II.

The LPW program was first enacted by Congress in 1976 and was extended by the Public Works Employment Act of 1977. The program's objectives were to create jobs, stimulate the economy out of the 1975-77 recession, and create usable public infrastructure. In order to attain these objectives, almost $6 billion was expended during 1977 and 1978 on over 10,000 public-facility construction projects in areas of high unemployment.6/

Table 6.1 presents selected LPW construction expenditures in three SMSA's--Denver, Colorado; Detroit, Michigan; and Wilmington, North Carolina.7/ In Denver, most expenditures were for new sewer construction. In Detroit, the expenditures were divided among five types of construction. In Wilmington, maintenance and repair of streets and highways was the only type of construction expenditure analyzed. The table shows expenditures in both current (1978) and constant (1972) dollars. Constant-dollar expenditures are included, because RIMS II coefficients and multipliers are based on 1972 output prices. The estimated LPW impacts discussed in the remainder of this chapter are also in 1972 constant dollars.

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5. The origin of the funds used to finance the final demand change provides an indication of whether substitution effects are relevant. In general, if the majority of funds originates from within (outside) the region, then substitution effects may be relevant (irrelevant). For a detailed presentation of the substitution effects, which are induced by various Federal urban policies, see Glickman (1980).

6. For additional details of the LPW program, see U.S. Department of Commerce (1977b).

7. These data were obtained from the Economic Development Administration (EDA). The construction types listed in table 6.1 represent some of the projects used by EDA in a detailed evaluation of the LPW program's effectiveness. For a list of all LPW expenditures, see U.S. Department of Commerce (1977a). Thus, the impacts analyzed here are not the impacts of the entire LPW program in each SMSA. For example, almost $25 million was expended in the Denver SMSA under the LPW program; the Denver expenditures shown in table 6.1 are approximately 25 percent of this total.

Table 6.1.-LPW Expenditures by Construction Type and SMSA

(Thousands of 1978 and 1972 dollars*)

SMSA	Construction type								Total
	Warehouses (49)	Other buildings (55)	Sewers (62)	Streets and highways (64)	Parks (70)	M & R residents (73)	M & R buildings (74)	M & R streets and highways (87)	
Denver, Colorado	350 (213)	- - -	4,072 (2,359)	- - -	220 (131)	- - -	- - -	- - -	4,642 (2,703)
Detroit, Michigan	- - -	8,572 (5,217)	- - -	4,272 (2,462)	- - -	833 (515)	1,899 (1,156)	2,017 (1,162)	17,593 (10,512)
Wilmington, North Carolina	- - -	- - -	- - -	- - -	- - -	- - -	- - -	1,240 (714)	1,240 (714)
Total	**350 (213)**	**8,572 (5,217)**	**4,072 (2,359)**	**4,272 (2,462)**	**230 (131)**	**833 (515)**	**1,899 (1,156)**	**3,257 (1,876)**	**23,475 (13,929)**

*1972 dollars are indicated in parenthesis.

In order to calculate the regional economic impacts of the LPW expenditures shown in table 6.1, RIMS II multipliers were estimated for each construction type in each SMSA. Table 6.2 shows the Inversion RIMS II multipliers, with households endogenous and the household row defined on an earnings basis.8/ As a reference point for indicating maximum multiplier size, the table also presents comparably defined United States multipliers for the eight construction types.9/ The multipliers show the effects of construction expenditures on gross output and earnings in each metropolitan area and the United States. For example, in Denver, an additional dollar (valued in 1972 constant dollars) of warehouse construction would lead to a total household earnings effect of approximately $.70. For Detroit, Wilmington, and the United States, the comparable effects would be $.72, $.54, and $1.07, respectively.

The multipliers presented in table 6.2 show considerable variation among construction types and across areas. For most construction types, the Denver and Detroit earnings multipliers are approximately 70 percent of the corresponding national values, while the Wilmington earnings multipliers are closer to 50 percent of the national values. This lower Wilmington percentage occurs because the regional economy in Wilmington is less self-sufficient than either Denver's or Detroit's. For example, since relatively few of the manufactured goods used in construction are supplied by the Wilmington economy, these inputs must be imported. As a result, multipliers are lower in Wilmington than in either Denver or Detroit, where more of these inputs are manufactured locally.

Despite the larger overall size of the Detroit SMSA, compared with the size of the Denver SMSA, the total multiplier levels in the two SMSA's are comparable in magnitude. This occurs because the degree of self-sufficiency in trade and service-type industries is slightly greater in the Denver SMSA, even though the degree of self-sufficiency in manufacturing is greater in the Detroit SMSA. To determine if this lesser degree of self-sufficiency in the trade and service-type industries was responsible for significantly lowering Detroit's multipliers, LQ's for trade and service-type industries were arbitrarily set equal to one, and a new set of multipliers was estimated. The results of this simulation indicated that the multipliers in Detroit averaged only 7 percent higher than those in Denver for the construction types analyzed here. These results would suggest that the effect of any underestimation of trade- and service-sector self-sufficiency in Detroit is of minor consequence in determining the levels of Detroit's multipliers.

In all three SMSA's, the RIMS II column multipliers are lowest for residential maintenance and repair. This result indicates that, among the construction types analyzed here, the smallest amount of construction inputs are supplied locally for residential maintenance and repair. Furthermore, within a given SMSA, multipliers vary

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8. The industry designations for the LPW program are shown in appendix table C1.1. Industry-specific multipliers for each SMSA and the United States are presented in appendix tables C2.1-C2.8.

9. It is important to recognize that the United States multipliers (based on an earnings-defined household row) are presented only to indicate the relative size of the regional multipliers calculated with the same household row definition. At the national level, a more appropriate household-row definition would include some nonearnings components of value added (for example, dividends, interest, and rent), which would generate additional household consumption. At the regional level, an earnings-defined household row is often used so that the dividends, interest, and rents that accrue to residents of other regions do not affect the impact region's gross-output levels. For an alternative treatment, see Bourque and Conway (1977).

Table 6.2.-Column-Total and Earnings Multipliers by Construction Type and Area

Area/multiplier type	Construction type							
	Warehouses (49)	Other buildings (55)	Sewers (62)	Streets and highways (64)	Parks (70)	M & R residents (73)	M & R buildings (74)	M & R streets and highways (87)
Denver, Colorado								
Earnings multiplier	0.704	0.710	0.646	0.644	0.699	0.660	0.702	0.781
Column-total multiplier	2.814	2.796	2.649	2.679	2.566	2.545	2.547	2.709
Detroit, Michigan								
Earnings multiplier	.723	.714	.633	.619	.701	.649	.697	.768
Column-total multiplier	2.839	2.772	2.586	2.538	2.540	2.470	2.501	2.615
Wilmington, North Carolina								
Earnings multiplier	.540	.538	.489	.514	.591	.531	.590	.675
Column-total multiplier	2.174	2.147	2.081	2.194	2.182	2.035	2.137	2.324
United States								
Earnings multiplier	1.066	1.074	.952	.917	.977	.964	1.028	1.040
Column-total multiplier	4.447	4.434	4.068	3.950	3.843	3.942	4.025	3.920

considerably among construction types (in Wilmington, for example, the earnings multipliers range from .489 to .675), and, therefore, LPW impacts will depend on the types of construction that were funded by the program.

In Denver and Detroit, column-total multipliers are highest for new warehouse construction. In all three SMSA's, however, earnings multipliers are highest for the maintenance and repair of streets and highways.10/ If the primary purpose of a study is to analyze impacts on local household earnings, this latter result indicates that focusing only on column-total multipliers may yield misleading conclusions about the relative magnitudes of impacts associated with various types of construction.

For the purpose of comparison, column-total and earnings multipliers were also estimated, using the alpha regression RIMS II approach; these results are presented in tables 6.3 and 6.4. A comparison of the alpha regression and inversion RIMS II results indicate that multiplier levels estimated by the two techniques are quite similar. For example, the inversion RIMS II column-total multipliers average less than 3 percent higher than the alpha regression RIMS II multipliers, and the inversion RIMS II earnings multipliers average 5 percent higher. Since the inversion RIMS II approach estimates the full multiplier matrix, and the results of the two RIMS II approaches are similar, the inversion RIMS II multipliers are used in the remainder of this chapter for analyzing the metropolitan-area economic impacts of selected LPW expenditures.

The initial LPW expenditures and RIMS II multipliers were multiplied to estimate the regional impacts of the LPW expenditures.11/ The impacts for each construction type were then summed to show the impacts of all selected LPW expenditures in each SMSA. The industry-specific gross output and earnings impacts are presented in table 6.5. Three of the results presented in this table should be noted here.

First, the industry-specific output impact in all three SMSA's is considerably greater than the earnings impact. This occurs because household earnings are always a small proportion of gross output, which, in I-O accounting, can be loosely defined as industry sales.12/ Miernyk, et al. (1970) and others have argued that focusing on gross output impacts is less important than focusing on earnings impacts. This is especially true for the regional impact analysis ofthe LPW program, since one of the objectives of

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10. The high earnings multiplier for maintenance and repair of streets and highways occurs because this construction type has the highest labor intensity (as measured by the direct household row coefficient) of the construction types analyzed here. Labor services are one construction input that are generally supplied locally. For a discussion of the elasticity of multipliers with respect to the size of household-row coefficients, see Cartwright (1980).

11. Equation 5.4a was used to calculate the gross output and total earnings impacts. Equation 4.13 was used to calculate the industry-specific earnings impacts. Impacts by construction type are presented in appendix tables C3.1-C3.3.

12. For details on I-O accounting, see Ritz (1979). Gross output in the I-O accounting framework includes all industry purchases. Gross regional product originating excludes intermediate purchases, and is similar in definition to regional value added. Since household earnings are a large percentage (at least 70 percent in most industries) of value added, the regional earnings impacts give an indication of the gross regional product originating and regional value-added impacts. For additional details on regional economic accounting, see Garnick and Grimes (1979) and Romans and Trott (1980).

Table 6.3.-Inversion RIMS II and Alpha Regression RIMS II Column-Total Multipliers by Construction Type and SMSA

Construction type	SMSA/multiplier type					
	Denver, Colorado		Detroit, Michigan		Wilmington, North Carolina	
	Alpha regression	Inversion	Alpha regression	Inversion	Alpha regression	Inversion
Warehouses (49)	2.788	2.814	2.731	2.839	2.145	2.174
Other buildings (55)	2.748	2.796	2.685	2.772	2.103	2.147
Sewers (62)	2.589	2.649	2.508	2.586	2.042	2.081
Streets and highways (64)	2.612	2.679	2.469	2.538	2.140	2.194
Parks (70)	2.531	2.566	2.492	2.540	2.162	2.182
M & R residents (73)	2.504	2.545	2.452	2.470	2.013	2.035
M & R buildings (74)	2.512	2.547	2.487	2.501	2.124	2.137
M & R streets and highways (87)	2.684	2.709	2.607	2.615	2.315	2.324

Table 6.4.-Inversion RIMS II and Alpha Regression RIMS II Earnings Multipliers by Construction Type and SMSA

Construction type	SMSA/multiplier type					
	Denver, Colorado		Detroit, Michigan		Wilmington, North Carolina	
	Alpha regression	Inversion	Alpha regression	Inversion	Alpha regression	Inversion
Warehouses (49)	0.690	0.704	0.679	0.723	0.528	0.540
Other buildings (55)	.683	.710	.671	.714	.521	.538
Sewers (62)	.618	.646	.602	.633	.481	.489
Streets and highways (64)	.620	.644	.588	.619	.501	.514
Parks (70)	.678	.699	.672	.701	.581	.591
M & R residents (73)	.641	.660	.632	.649	.515	.531
M & R buildings (74)	.682	.702	.680	.697	.580	.590
M & R streets and highways (87)	.767	.781	.753	.768	.669	.675

Table 6.5.-Gross Output and Earnings Impacts of LPW Expenditures by Industry and SMSA

(Thousands of 1972 dollars)

Industry	SMSA/impact category					
	Denver, Colorado		Detroit, Michigan		Wilmington, North Carolina	
	Gross output	Earnings	Gross output	Earnings	Gross output	Earnings
1 Agriculture	17	4	35	7	4	2
2 Forestry and fisheries	0	0	0	0	1	0
3 Coal mining	2	1	0	0	0	0
4 Petroleum and natural gas mining	9	1	1	0	0	0
5 Other mining	38	9	69	21	42	13
6 New construction	2,704	868	7,680	2,611	0	0
7 Maintenance and repair	45	20	3,009	1,335	726	340
8 Food and kindred products	126	18	346	50	8	2
9 Textiles	1	0	8	2	7	2
10 Apparel	11	3	19	5	11	3
11 Paper	8	2	22	6	1	0
12 Printing and publishing	40	14	86	35	3	2
13 Chemicals	57	11	437	82	11	2
14 Rubber and leather	12	4	155	40	0	0
15 Lumber and furniture	10	3	100	29	3	1
16 Stone, clay, and glass	285	85	438	130	14	3
17 Primary metals	104	36	528	140	0	0
18 Fabricated metals	144	35	801	251	2	0
19 Nonelectrical machinery	108	37	164	62	0	0
20 Electrical machinery	12	5	58	19	0	0
21 Motor vehicles	0	0	323	44	0	0
22 Other transportation equipment	1	0	15	6	1	0
23 Instruments	12	4	10	4	0	0
24 Miscellaneous manufacturing	8	2	45	14	0	0
25 Transportation	172	70	664	302	59	21
26 Communication	64	20	199	64	14	5
27 Utilities	72	9	361	46	21	3
28 Wholesale trade	241	100	771	325	34	14
29 Retail trade	225	103	947	438	62	27
30 Eating and drinking establishments	102	35	351	121	26	8
31 Finance	77	24	214	67	11	3
32 Insurance	84	36	296	130	8	3
33 Real estate	167	8	431	22	40	2
34 Lodging and amusement	36	12	97	33	7	2
35 Personal services	37	18	151	73	5	2
36 Business services	221	93	1,037	456	21	9
37 Health services	48	18	360	137	14	4
38 Other services	123	51	408	156	23	8
39 Household	1,767	8	7,288	25	483	2
Total*	**5,423**	**1,767**	**20,636**	**7,288**	**1,179**	**483**

*Gross output totals exclude earnings impacts to avoid double counting; see equation 4.12.

the program was job creation, which can be measured by the household earnings impacts of the program.13/

Second, in table 6.3, the total-earnings impact (which is shown as the last row entry in the gross output column for each SMSA) is equal to the sum of the industry-specific earnings effects. For example, in the Denver SMSA, the total-earnings impact is $1,767 thousand, which is equal to the sum of the industry-specific earnings impacts.

Third, it is useful to indicate the size of total-earnings impacts relative to the initial LPW expenditures. For example, in the Denver SMSA, the $2,703 thousand in LPW expenditures generated a total of $1,767 thousand in local area earnings. The ratio of local-area-earnings impacts to LPW expenditures is .65 in Denver; the ratios in Detroit and Wilmington are .69 and .68, respectively. The two higher ratios indicate that the LPW expenditures in the other two SMSA's were associated with construction types that have higher earnings multipliers than those in Denver.

The gross-output and earnings impacts presented in table 6.5 indicate that a large proportion of the total impacts occurs within the construction industries (New Construction, and Maintenance and Repair) themselves. In order to show the relative size of the industry-specific impacts, the percent distribution of LPW earnings impacts by industry for each SMSA is presented in table 6.6. The table indicates that in Denver and Detroit, slightly more than 50 percent of the industry-specific impacts occur in the construction industries. In Detroit, the next largest earnings impacts occur in the Transportation, Wholesale and Retail Trade, and Business Services industries. In Wilmington, 70 percent of the total earnings impacts occur in the construction industries, a further indication that a large part of the initial LPW expenditure leaks out of Wilmington.

In concluding this discussion, it is important to recognize that the analysis of regional gross-output and earnings impacts does not represent an analysis of all LPW regional economic impacts. For example, one important set of effects, fiscal impacts in terms of sales and income-tax receipts, cannot be measured by RIMS II itself. However, RIMS II estimated-output changes in retail trade can provide the basis for estimating sales-tax receipts, and estimated pretax household-earnings changes can provide the basis for estimating income-tax receipts. Furthermore, it is important to recognize that the RIMS II estimated impacts by themselves do not represent a cost-benefit analysis of the LPW program.14/ For example, if the LPW expenditures in one region were financed by

13. Data on industry-specific earnings per worker and earnings impacts can be used to estimate industry-specific employment impacts. For example, if average earnings per worker in Denver is $10,000 (1972 constant dollars) in retail trade, and the LPW retail-trade earnings impact is $103,000, then the LPW program could lead to the hiring of 10 retail-trade workers. However, employment impacts are particularly difficult to specify exactly, based on average earnings. For example, the $103,000 could accrue to workers already employed, in the form of overtime earnings, or it could be used to hire 20 part-time workers at $5,000 per worker. In all probability, the employment impacts of most final demand changes are a mixture of full-time, part-time, and overtime workers.

14. For additional details on the relationship of cost-benefit analysis and impact analysis, see Haveman (1977) and Haveman and Margolis (1977). Often regional impact analysis and national cost-benefit analysis are not linked in a policy study. For example, decisions on the opening and closing of military facilities are made on the basis of national defense considerations, while the regional impact analysis of a particular opening or closing is often undertaken in order to indicate the size of impact assistance required to ameliorate any unfavorable regional effects of those decisions. For a discussion of the impacts of military-base-spending cutbacks, see Cartwright and Beemiller (1979).

Table 6.6.-Percent Distribution of LPW Earnings Impacts by Industry and SMSA

(Percent)

Industry	SMSA		
	Denver, Colorado	Detroit, Michigan	Wilmington, North Carolina
1 Agriculture	0.2	0.1	0.2
2 Forestry and fisheries	0	0	0
3 Coal mining	.1	0	0
4 Petroleum and natural gas mining	.1	0	0
5 Other mining	.5	.3	2.7
6 New construction	49.1	35.8	0
7 Maintenance and repair	1.1	18.3	70.4
8 Food and kindred products	1.0	.7	.2
9 Textiles	0	0	.2
10 Apparel	.2	.1	.6
11 Paper	.1	.1	0
12 Printing and publishing	.8	.5	.2
13 Chemicals	.6	1.1	.4
14 Rubber and leather	.2	.5	0
15 Lumber and furniture	.2	.4	.2
16 Stone, clay, and glass	4.8	1.8	.6
17 Primary metals	2.0	1.9	0
18 Fabricated metals	2.0	3.5	0
19 Nonelectrical machinery	2.1	.9	0
20 Electrical machinery	.2	.3	0
21 Motor vehicles	0	.4	0
22 Other transportation equipment	0	.1	0
23 Instruments	.2	.1	0
24 Miscellaneous manufacturing	.1	.2	0
25 Transportation	4.0	4.1	4.3
26 Communication	1.1	.9	2.0
27 Utilities	.5	.6	.6
28 Wholesale trade	5.7	4.5	2.9
29 Retail trade	5.8	6.0	5.6
30 Eating and drinking establishments	2.0	1.7	1.7
31 Finance	1.4	.9	.6
32 Insurance	2.0	1.8	.6
33 Real estate	.5	.3	.4
34 Lodging and amusement	.7	.5	.4
35 Personal services	1.0	1.0	.4
36 Business services	5.3	6.3	1.9
37 Health services	1.0	1.9	.8
38 Other services	2.9	2.1	1.7
39 Household	.5	.3	.4
Total	**100.0**	**100.0**	**100.0**

income taxes generated in other regions, there would be a positive impact in the one region, and negative impacts (through a decline in personal consumption expenditures) elsewhere; net national benefits could be viewed as the sum of the positive single-region impacts and the negative rest-of-Nation impacts. However, RIMS II results could be used in a national-level cost-benefit analysis of various programs, to estimate separately the positive and negative regional impacts in the above example.

It it evident that in many regional economic-impact studies, RIMS II results can be crucial for estimating important economic effects that are not directly specified by RIMS II itself. Regional fiscal effects, labor migration effects, and environmental and energy effects are examples of important regional economic impacts that often depend on estimates of the regional gross-output and earnings effects of the initial stimulus. Since many of these important effects are often best analyzed on a case-by-case basis, one of the major advantages of using RIMS II is that valuable research resources can be used in the analysis of these effects, rather than on the construction of a gross-output and earnings impact model. Therefore, when using RIMS II a cost-effective impact study might devote most of its research budget to specifying initial impacts in industry-specific detail, and analyzing the implications of the RIMS II estimated gross-output and earnings impacts on other important aspects of regional economic activity.

Chapter 7

CONCLUSIONS

The purpose of this chapter is to discuss the advantages and limitations of RIMS II and to indicate several extensions of the basic RIMS II model.

Advantages of RIMS II

Four major advantages of RIMS II should be mentioned; the first three concern the flexibility of the modeling system and the fourth concerns its accuracy. First, RIMS II was constructed as a highly disaggregated system, both spatially and industrially. Consequently, it can be used to evaluate regional impacts for any county or group of counties, and for any industry included in the 496-industry national I-O model. Second, RIMS II was constructed to rely on a minimal number of data sources, including the 1972 national I-O table and the BEA 4-digit Standard Industrial Classification (SIC) earnings-by-county file. As a result, RIMS II is relatively inexpensive to implement, even though the industrial and spatial data contained in these files are substantial. Third, because the system is capable of generating multiplier estimates, using either the inversion approach or the shortcut alpha regression approach, RIMS II has greater flexibility in application than many other techniques.

Fourth, both RIMS II approaches, when compared with the multipliers from survey-based I-O tables, are relatively accurate.1/ For example, the average error associated with the RIMS II approaches is well within an acceptable range (approximately 5 percent), and, for the majority of individual multiplier columns, RIMS II and survey multiplier differences are small; furthermore, for a given column in the multiplier matrix, both RIMS II and survey multipliers have similar row distributions of the column-total multiplier.

Limitations of RIMS II

Like other regional models, RIMS II suffers from certain limitations that affect the manner in which it should be employed.2/ Three of the more significant limitations are descibed here.

First, RIMS II was developed as a single-region model, because the annual, detailed trade-flow data necessary to make RIMS II an interregional model are not available. Therefore, the impact estimates obtained from the modeling system do not take into

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1. As indicated in chapters 4, 5, and 6 of this monograph, the accuracy of impacts estimated by RIMS II can be improved by gathering survey data on the initial economic change that is the subject of the impact study. For improving the accuracy of the RIMS II multipliers themselves, survey data can be gathered for specific regional interindustry linkages, and RIMS II results can be used as the purely nonsurvey component of a "mixed-approach" table (as described in chapter 2). In order to specify what survey data to gather, future research will be directed at identifying the interindustry coefficients that generate the larger differences between RIMS II and survey multipliers.

2. The limitations of RIMS II and most other I-O models (whether survey-based or nonsurvey-based) are the same. One group of I-O limitations, particularly those relating to the fixed-proportions production function, is discussed in chapter 6 and is not repeated here.

account feedback effects from adjacent or economically related regions. Second, RIMS II is a static model rather than a dynamic model. Consequently, the impact estimates generated by the system indicate the overall change that is likely to occur rather than the timing of such a change.

Third, government and investment spending are exogenous in RIMS II and are viewed as elements of final demand. Therefore, RIMS II by itself cannot estimate changes in government spending that are induced by changes elsewhere in the model. The exogenous treatment of these sectors is due to the conventions adopted in the national I-O table and the lack of regional data for these sectors.

Model Extensions

While the limitations described in the previous section are significant, their effects can be ameliorated in particular applications of RIMS II. The remainder of this chapter describes three applications in which the basic modeling system can be extended to overcome partially its limitations.3/

An interregional application

In assessing regional impacts of urban public-expenditure programs, it is often useful to determine the impact in the urban-core county versus the impact in the remainder of the SMSA, and how the distribution of the impact would differ depending on whether the initial expenditure took place in the urban-core county or in surrounding suburban counties.

Such an application was undertaken by BEA for the U.S. Department of Housing and Urban Development (HUD).4/ In this application, industry-specific multipliers for the entire SMSA first were calculated. Next, direct requirements provided by suburban firms to the core county and by core-county firms to suburban counties were estimated, based on industrial structure and commuting data. The data on direct requirements then were used to estimate preliminary interregional matrices of multipliers for the core and suburban counties. Finally, the SMSA multipliers were allocated between the core county and suburban counties, based on the preliminary interregional matrices. The resulting final estimates indicate the impact of changes in one region (e.g., the core county) on an adjacent region (e.g., the suburban counties).

A dynamic application

Impact analysis often requires estimates of the timing and magnitude of the impacts of policy changes. While I-O models can be used to estimate the magnitude of impacts in considerable industrial detail, because they are static in structure, they do not address the timing of the impacts. Alternately, econometric models that identify explicitly the time path of impacts usually lack the industrial detail provided by I-O models. One approach for analyzing both the timing and the magnitude of impacts is to combine the results of a regional I-O model and a regional econometric model.5/

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3. While the extensions of the modeling system described below were initially made in applications of the original RIMS, they are presented here, since they will be employed, where appropriate, in future RIMS II applications.

4. See Cartwright (1980).

5. The advantages and limitations of the various techniques for combining I-O and econometric models are discussed in Kort and Cartwright (1981).

The above approach was employed by HUD in the analysis of the regional impacts of construction expenditures in Colorado.6/ In this application, the BEA multiregional econometric model, NRIES, was used to estimate the timing and magnitude of the impacts on the 13 endogenous industries specified in the model, and the original RIMS model was used to estimate the magnitude of the impacts on over 300 endogenous industries specified in the model and present in Colorado. While it would have been preferable to obtain more industrially detailed data on timing, the estimates from NRIES and RIMS provided considerable information on which to base an evaluation of the overall dynamic impacts and the detailed industry-specific impacts.

A government-sector application

As indicated above, the national I-O table includes the government sector in final demand rather than as an endogenous activity. Therefore, it is not possible to analyze directly the effects on the remainder of the economy when the level of regional government expenditures is affected by final demand changes that originate in the private sector. However, it is possible to analyze the effects of changes in regional government expenditures, if information can be obtained on the type of regional government-sector purchases and payments to residents in the region.

Such an approach was employed at BEA in assessing the regional impact of the cutbacks in military-base spending that were planned by the U.S. Department of Defense.7/ In this application, region-specific information was obtained, identifying the local purchases made by the base and its personnel, as well as wage-and-salary payments to local residents. These expenditures then were treated as changes in final demand, and were employed in generating the industry-specific estimates of impacts that were associated with the reduction of military-base spending in the region.

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6. See Ballard, Cartwright, Gustely, and Kort (1980).

7. See Cartwright and Beemiller (1979).

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Appendix A

SECTORING OF THE SURVEY-BASED TABLES

Tables A1.1-A1.3 present the sectoring schemes employed in the Texas, Washington, and West Virginia survey-based I-O tables. Several observations concerning this sectoring scheme should be made here.

In general, these regional tables, when compared to the national I-O table, provide more industrial detail in the trade sector and those sectors that are of special importance in the State. For example, in the Texas table, the trade sector is disaggregated into 17 industries as compared to only 2 in the national table. In Washington and West Virginia, more detail is provided for the natural resource related industries. Specifically, West Virginia makes a distinction between underground and strip mining whereas the national table does not. A similar sectoring problem is encountered in the Washington table, where forestry and fisheries are separate industries, unlike in the national table. Therefore, the survey tables were aggregated to a level of industrial detail that permited comparisons to be made with the nonsurvey tables.

The manner in which the "owner-occupied dwellings" (I-O industry 710100) sector is treated in the nonsurvey table, depended upon the convention adopted by the survey-based table. Since the Texas and West Virginia tables do not explicitly recognize this industry, in the nonsurvey tables, industry 710100 was deleted as a column industry, and the PCE column coefficients were based on a column total that excluded the row element associated with industry 710100. In the Washington table, industry 710100 was treated as part of the value-added component of PCE. Adjustments for this convention were made by deleting row industry 710100 and combining the column elements of industry 710100 with the respective PCE column elements.

The resulting number of column industries is 133 for Texas, 52 for Washington, and 41 for West Virginia. The row industries of the regional tables were aggregated, where possible, to industry classifications that were consistent with those employed in the BEA OBERS projections program.1/ The aggregations of rows to insure conformability with the OBERS industries is part of RIMS II for two reasons. First, in future applications, this operation will permit the estimation of industry-specific employment impacts, since the OBERS regional data base includes compatibly estimated earnings and employment subfiles. Second, row aggregation assures that the confidential 4-digit SIC earnings data used to estimate the LQ's in RIMS II will not be disclosed inadvertently. As a result, for this analysis the Texas table contains 51 rows, the Washington table contains 26 rows, and the West Virginia table contains 34 rows.

For the comparisons in chapter 5, the 1975 West Virginia transactions table was deflated to 1972 dollars in order to minimize distortions due to interindustry differences in the rates of price change.2/ In addition, the comparisons shown in chapter 5 are based on a value-added definition of the household row in Washington, and an earnings definition of the household rows in Texas and West Virginia. These definitions were employed to conform to the conventions adopted in the respective State tables.

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1. See U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business (November 1980), for a description of OBERS.

2. The deflation of the 1975 West Virginia table used a "double deflation" technique similar to the one described in BEA Staff Paper No. 32, Updated Input-Output Table of the U.S. Economy: 1972, by Paula C. Young and Philip M. Ritz, April 1979.

Table A1.1.-Input-Output Industry Definitions

Texas

Industry number Column	Industry number Row	Industry name	1972 SIC
Agriculture, forestry, and fisheries			
4	1	Irrigated cotton	0131
5	1	Irrigated food grains	0111,0112
6	1	Irrigated feed grains	0115,0119
7	1	Other irrigated crops	0116,0133,0134,0139,0161,0171,0172, 0173,0174,0175,0179,0191
4	1	Dryland cotton	0131
5	1	Dryland food grains	0111,0112
6	1	Dryland feed grains	0115,0119
7	1	Dryland crops and livestock not elsewhere classified	0116,0133,0134,0139,0161,0171,0172,0173, 0174,0175,0179,0191,0271,0272,0279,0291
3	1	Range livestock production	0212,0214,0219
3	1	Feedlot livestock production	0211,0213
1	1	Dairy	0241
2	1	Poultry and eggs	0251,0252,0253,0254,0259
115	37	Agriculture supply except farm machinery	5191
9	2	Cotton ginning	0724
9	2	Agricultural services	0711,0721,0722,0723,0729,0741,0742,0751, 0752,0761,0762,0781,0782,0783,0971
8	8	Primary forestry	0811,0821,0843,0849,0851
8	3	Fisheries	0912,0913,0919,0921
Mining			
11	5	Crude petroleum and natural gas	1311
11	5	Natural gas liquids	1321
11	5	Oil and gas field services	1381,1382,1389
10	4	Other mining and quarrying	1011,1021,1031,1051,1061,1081,1092, 1094,1099,1211,1213,1411,1422,1423, 1429,1442,1446,1452,1453,1454,1455, 1459,1472,1473,1474,1475,1476,1477, 1479,1481,1492,1496,1499
Construction			
12	6	Residential construction	1521,1522,1531 plus subcontractors parts of the two-digit SIC 17
14	6	Commercial, educational, and institutional construction	1542, plus subcontractors parts of two-digit SIC 17
13	6	Industrial construction	1541, plus subcontractors parts of two-digit SIC 17
15	6	Facility construction	1611,1622,1623,1629
16	6	Maintenance and repair	Maintenance and repair part of 2-digit SIC 17

Table A1.1.-Input-Output Industry Definitions--Continued

Texas

Industry number Column	Row	Industry name	1972 SIC
Manufacturing			
18	7	Meat products	2011,2013
19	7	Poultry products	2016,2017
20	7	Dairies	2021,2022,2023,2024,2026
22	7	Grain milling	2041,2043,2044,2045,2046
23	7	Animal feeds	2047,2048
24	7	Bakery products	2051,2052
21	7	Canned, preserved, pickled, dried, and frozen foods	2032,2033,2034,2035,2037,2038,2091,2092
25	7	Other food and kindred products	2061,2062,2063,2065,2066,2067,2074,2075, 2076,2077,2079,2095,2097,2098,2099,2121
26	7	Beverages	2082,2084,2086,2087
27	8	Textile mill products	2211,2221,2231,2241,2251,2253,2254,2257, 2258,2259,2261,2262,2269,2271,2272,2279, 2281,2283,2284,2291,2292,2293,2294,2295, 2296,2297,2298,2299
28	9	Men and boys, women and misses, and children furnishings	2311,2321,2322,2323,2327,2328,2329,2331, 2335,2337,2339,2341,2342,2351,2352,2361, 2363,2369
29	9	Related apparel	2371,2381,2384,2385,2386,2387,2389,2391, 2392,2393,2394,2395,2396,2397,2399
30	10	Logging	2411
31	10	Lumber mills	2421,2426,2429
32	10	Millwork and wood products	2431,2434,2435,2436,2439,2441,2448,2449, 2452,2491,2492,2499
33	11	Wood furniture and fixtures	2511,2512,2515,2517,2519,2521,2531,2541, 2591,2599
34	11	Metal furniture and fixtures	2514,2522,2542
35	12	Paper and paper mills	2611,2621,2631,2661
36	12	Paper products except boxes and containers	2641,2642,2643,2645,2646,2647,2648,2649
37	12	Boxes and paper containers	2651,2652,2653,2654,2655
38	13	Newspapers	2711
39	13	Publishing	2721,2731,2741
40	13	Printing	2732,2751,2752,2753,2795
41	13	Manifold business forms	2761
42	13	Other printing and publishing	2771,2782,2789,2791,2793,2794
43	14	Chlorine and alkalies	2812,2813
43	14	Cyclic crudes and intermediates and inorganic pigments	2865
45	14	Organic chemicals	2861,2869
43	14	Inorganic chemicals	2816,2819
47	14	Fibers and plastics	2821,2823,2824
48	14	Synthetic rubber	2822
49	14	Drugs	2831,2833,2834
44	14	Agricultural chemicals	2873,2874,2875,2879

Table A1.1.-Input-Output Industry Definitions--Continued

Texas

Industry number: Column	Industry number: Row	Industry name	1972 SIC
Manufacturing (continued)			
50	14	Soaps, cleansers, and toiletries	2841,2842,2843,2844
51	14	Paints and varnishes	2851
46	14	Other chemicals	2891,2892,2893,2895,2899
52	15	Petroleum refining	2911
53	15	Other petroleum products	2951,2952,2992,2999
54	16	Tires	3011
55	16	Fabricated rubber products	3021,3041,3069
56	16	Plastics products	3079
57	17	Leather and leather products	3111,3131,3142,3143,3144,3149,3151,3161, 3171,3172,3199
58	18	Glass	3211,3221,3229,3231
60	18	Clay	3251,3253,3255,3259,3261,3262,3269
61	18	Cut stone and other clay and shell products	3281,3291,3292,3293,3295,3296,3297,3299, 3274,3275
59	18	Cement and concrete products	3241,3271,3272,3273
62	19	Primary steel and iron	3313,3315,3316,3317
64	19	Foundries	3321,3322,3324,3325
67	19	Nonferrous primary and secondary smelting	3331,3332,3333,3339,3341
68	19	Aluminum smelting and nonferrous rolling and drawing	3334,3351,3353,3354,3356,3357
66	19	Castings and forgings	3361,3362,3369,3398,3399
71	20	Fabricated steel	3441
73	20	Plate work	3443
74	20	Sheet metal and architectural	3444,3446,3448,3449
72	20	Metal doors	3442
69	20	Fabricated metal products	3411,3412,3421,3423,3425,3429
70	20	Plumbing	3431,3432,3433
65	20	Bolts, nuts, and screws	3451,3452,3461,3462,3463,3465,3466,3469
75	20	Electroplating, coating, and engraving	3471,3479
77	20	Valves and pipe fittings	3494,3498
76	20	Other fabricated metal	3493,3495,3496,3497,3499
79	21	Farm, construction, and industrial machinery	3523,3524,3531,3537
81	21	Materials handling machinery and equipment	3534,3535,3536
80	21	Mining machinery and equipment	3532,3533
78	21	Engines	3511,3519
82	21	Metal working machinery	3541,3542,3544,3545,3546,3547,3549
83	21	Industrial processing machinery	3551,3552,3553,3554,3555,3559
84	21	General industry machinery	3561,3562,3563,3564,3565,3566,3567,3568, 3569
86	21	Refrigerator machinery	3585
85	21	Computers, and accounting, office, and service industry machinery	3572,3573,3574,3576,3579,3581,3582,3586, 3589,3592,3599

Table A1.1.-Input-Output Industry Definitions--Continued

Texas

Industry number: Column	Industry number: Row	Industry name	1972 SIC
Manufacturing (continued)			
88	22	Electric household equipment	3631,3632,3633,3634,3635,3636,3639
90	22	Electronic communications equipment	3651,3652,3661,3662,3671,3672,3673,3674, 3675,3676,3677,3678,3679
91	22	Other electrical apparatus	3691,3693,3694,3699
92	23	Aircraft	3721,3761
93	23	Aircraft engines	3724,3764
94	23	Other aircraft	3728,3769
95	24	Motor vehicles and parts	3711,3713,3714,3715
96	23	Ship and boat building	3731,3732
97	23	Other transportation equipment	3743,3751,3792,3799,2451
98	26	Scientific instruments	3811
87	26	Mechanical measuring devices	3821,3823,3824,3829,3825
99	26	Medical instruments	3841,3842,3843
100	26	Photographic time and optical instruments	3832,3851,3861,3873
101	27	Other manufacturing industries	3911,3914,3915,3931,3951,3952,3953,3955, 3961,3962,3963,3964,3991,3993,3995,3996 3999
102	27	Games and toys	3942,39444,3949
Transportation			
103	28	Railroad transportation	4011,4013,4041
104	29	Intercity rural highway transportation	4131
117	39	Motor freight transportation and local trucking and storage	4212,4213,4214,4222,4224,4225,4231
106	31	Water transportation	4411,4421,4441,4452,4453,4454,4459,4463, 4464,4469
107	32	Air transportation	4511,4521,4582,4583
108	33	Pipeline transportation	4612,4613,4619
104	29	Local and suburban transportation	4111,4119,4121
109	34	Other transportation services	4141,4142,4151,4171,4172,4712,4722,4723, 4742,4782,4783,4784,4789
Communication			
110	35	Telephone and telegraph	4811,4821
111	33	Radio and television	4832,4833
110	35	Other communications	4899
113	36	Gas services	4922,4923,4924,4925,4932
112	36	Electric services	4911,4931
114	36	Water and sanitary services	4941,4952,4953,4959,4961

Table A1.1.-Input-Output Industry Definitions--Continued

Texas

Industry number: Column	Industry number: Row	Industry name	1972 SIC
Wholesale trade			
115	37	Wholesale auto, parts, and supplies	5012,5013,5014
115	37	Wholesale groceries and related products	5141,5142,5143,5144,5145,5146,5146,5148, 5149
115	37	Wholesale farm products and farm product warehousing	4221,5152,5153,5159
115	37	Wholesale livestock	5154
115	37	Wholesale machinery, equipment, and supplies	5081,5082,5084,5085,5086,5087,5088
115	37	Wholesale petroleum and petroleum products	5171,5172
115	37	General wholesale	5021,5023,5031,5039,5041,5042,5043,5051, 5052,5063,5064,5065,5072,5074,5075,5078, 5093,5094,5099,5111,5112,5113,5122,5133, 5134,5136,5137,5139,5161,5181,5182,5194, 5198,5199
Retail trade			
116	38	Lumber yards	5211
116	38	Farm machinery and equipment	5083
116	38	Hardware, paint, and wallpaper	5231,5251
116	38	Department and variety stores	5311,5331,5399,5961
116	38	Food stores	5411,5422,5423,5431,5441,5451,5462,5463, 5499
116	38	Automotive dealers and repair shops	5511,5521,5531,7531,7534,7535,7538,7539, 7542,7549
116	38	Gasoline service stations	5541
116	38	Apparel and accessory stores	5611,5621,5631,5641,5651,5661,5681,5699
116	38	Furniture	5712,5713,45714,5719,5722,5732,5733
125	38	Eating and drinking places	5812,5813
116	38	Other retail	5261,5271,5551,5561,5571,5599,5912,5921, 5931,5941,5942,5943,5944,5945,5946,5947, 5948,5949,5962,5963,5982,5983,5984,5992, 5993,5994,5999
Finance, insurance, and real estate			
117	39	Banking and credit agencies	6011,6022,6023,6024,6025,6026,6027,6028, 6032,6033,6034,6042,6044,6052,6054,6055, 6056,6059,6112,6113,6122,6123,6124,6125, 6131,6142,6143,6144,6145,6146,6149,6153, 6159,6162,6163

Table A1.1.-Input-Output Industry Definitions--Continued

Texas

Industry number Column	Row	Industry name	1972 SIC
Finance, insurance, and real estate (continued)			
119	41	Insurance carriers	6311,6321,6324,6331,6351,6361,6371,6399, 6411
118	40	FIRE not elsewhere classified	6211,6221,6231,6281,6512,6513,6514,6515, 6517,6519,6531,6541,6552,6553,6611,6711, 6722,6723,6724,6725,6732,6733,6792,6793, 6794,6799
Services			
124	50	Legal services	8111
120	42	Lodging services	7011,7021,7032,7033,7041
121	43	Personal services	7211,7212,7213,7214,7215,7216,7217,7218, 7219,7231,7241,7251,7261,7271,7299
123	44	Advertising	7311,7312,7313,7319
122	44	Duplicating and addressing	7331,7332,7339
122	44	Employment agencies, private	7361
122	44	Photographic services	7221,7333,7813,7814,7819,7823,7824,7829, 7395
122	44	Research and development	7319,8922
122	44	Other business services	7321,7341,7342,7349,7351,7362,7369,7392, 7393,7394,7395,7396,7397,7399
127	46	Motion picture, amusement, and recreation services	7832,7833,7911,7922,7929,7932,7933,7941, 7948,7992,7993,7996,7997,7999
126	45	Automobile rental services	7512,7513,7519
126	45	Automobile parking	7523,7525
121	43	Electrical repair	7622,7623,7629
121	43	Miscellaneous repair services	7631,7641,7692,7694,7699
128	47	Physicians and dentists services	8011,8021,8031,8041
129	47	Hospital and laboratory services	8062,8063,8069,8071,8072
130	26	Other health services	8042,8049,8081,8091
	*	Education (public and private)	8211
	*	Colleges and universities	8221,8222
131	48	Other educational services	8231,8241,8243,8244,8249,8299
124	50	Engineering and architectural services	8911
124	50	Accounting, auditing, and bookkeeping	8931,7372,7374,7379
124	50	Other professional services	8999
132	49	Other services	8321,8331,8351,8361,8399,8411,8421,8611, 8621,8631,8641,8651,8661,8699
Other manufacturing			
17	25	Ordnance and ordnance accessories	3482,3483,3484,3489,3761,3795

Table A1.1.-Input-Output Industry Definitions--Continued

Texas

Industry number: Column	Industry number: Row	Industry name	1972 SIC
Other services			
	*	Outdoor recreation	The total public funds spent in the operation and administration of outdoor recreation facilities by the Texas Parks and Wildlife Department, plus those funds spent by counties, cities, and municipalities for the same purpose.
132	49	Scrap	Used and second-hand goods.
Final payments			
133	51	Households	Wages, salaries, rents, interest, and dividends paid to households and personal incomes of sole proprietors.

*These State and local activities are not included in the endogenous portion of the table.

Table A1.2.-Input-Output Industry Definitions

Washington

Industry number: Column	Industry number: Row	Industry name	1972 SIC
1	2	Field and seed crops	011,013 (exc. 0133), pt. 018, pt. 019
2	1	Vegetables and fruits	0133,016,017, pt. 019
3	1	Livestock and products	02 (exc. 027)
4	1	Other agriculture	pt. 018,027,071
5	1	Fisheries	09 (exc. 097)
6	2	Meat products	201
7	2	Dairy products	202
8	2	Canning and preserving	203,2091,2092
9	2	Grain meal products	204
10	2	Beverages	208
11	2	Other foods	205-207,2095-2099
12	3	Textiles	22
13	4	Apparel	23
14	5	Mining	10-14
15	1	Forestry	08--includes national and State forests
16	6	Logging	241
17	6	Sawmills	242
18	6	Plywood	2435,2436
19	6	Other wood products	2431,2434,2439,244,245,2495
20	7	Furniture and fixtures	25
21	8	Pulp mills	261
22	8	Paper mills	262
23	8	Paperboard and other products	263-266
24	9	Printing and publishing	27
25	10	Industrial chemicals	281,286,287,289
26	10	Other chemicals	282-285
27	11	Petroleum	29
28	12	Glass products	321-323
29	12	Cement, stone, and clay	324-329
30	13	Iron and steel	331,332,339
31	13	Other nonferrous metals	3331-3333,3339,334 3351,3356,3357,3362,3369
32	13	Aluminum	3334,3353-3355,3361
33	14	Structural metal products	344
34	14	Other fabricated metals	341-343,345-349
35	15	Nonelectrical industrial equipment	355-358
36	15	Machine tools and shops	354,359
37	15	Nonelectrical industrial equipment	355-358
38	16	Electrical machinery	36
39	17	Aerospace	372,376
40	17	Motor vehicles and other transportation equipment	371,374,375,379

Table A1.2.-Input-Output Industry Definitions--Continued

Washington

Industry number		Industry name	1972 SIC
Column	Row		
41	17	Ship and boat building	373--includes Puget Sound Naval Shipyard
42	18	Other manufacturing	30,31,38,39
43	19	Transportation services	40-47--includes Postal Services, State ferries, and public transit
44	20	Electric companies	491, pt. 493--includes BPA, PUD's, and municipal electric utilities
45	20	Gas companies	492, pt. 493--includes municipal gas companies
46	20	Other utilities	pt. 493,494-497--includes public water, sewage, sanitary, and irrigation systems
47	21	Communication	48
48	22	Construction	15-17
49	23	Trade	50-59--includes State liquor stores
50	24	Finance, insurance, and real estate	60-67
51	25	Services	072-079,097,70-89--excludes public hospitals and schools
52	26	Households	

Table A1.3.-Input-Output Industry Definitions

West Virginia

Industry number: Column	Industry number: Row	Industry name	1972 SIC
1	1	Agriculture	0133,0139,0143,0132,011,012, 0142,0144,019,07,08,09
2	2	Coal mining (underground)	121
2	2	Coal mining (strip and auger)	121
3	3	Petroleum and natural gas	13
4	4	All other mining	10,14
-	-	General contractors (building)	15
-	-	General contractors (nonbuilding)	16
-	-	Special trades contractors	17
5	5	Food and kindred products (n.e.c.)	201,203,204,209
6	5	Food and kindred products (dairies)	202
7	5	Food and kindred products (bakeries)	2051
8	5	Food and kindred products (beverages)	208
9	6	Apparel and accessories	23
10	7	Logging and sawmills	241,242
11	7	Furniture and other wood fabrication	243,244,249,25
12	8	Printing and publishing	27
13	9	Chemicals	28
14	10	Petroleum	29
15	11	Glass	321,322
16	11	Stone and clay products	32 (excluding 321,322,329)
17	12	Primary metal products	33
18	13	Fabricated metal products	34
19	14	Machinery (except electrical)	35
20	15	Electrical machinery and apparatus	36
21	16	Transportation equipment	37
22	17	Instruments and related products	38
23	18	All other manufacturing	21,22,30,329,39,19,26,31
24	19	Eating and drinking establishments	58
25	20	Wholesale trade	50
26	21	All other retail	53,55 (except 5541), 56,57,59
27	22	Banking	60
28	23	Other finance	61
29	24	Insurance agents and brokers	64
30	25	Real estate	65
29	24	All other FIRE	62,63,66,67
31	26	Hotels and other lodging places	70
32	27	Medical and legal services	80,81
33	28	Educational services	82 (including 9182,9282,9382)
34	29	Railroads	40
35	30	Trucking and warehousing	42
36	31	All other transportation	44,41,45,46,47
37	32	Communication	48
38	33	Electric companies and systems	491
39	33	Gas companies and systems	492
40	33	Water and sanitary services	494,495,496 (including 9249,9349)
41	34	Households	

Appendix B

DATA FOR SEVERAL ACCURACY COMPARISONS

Table B1.1.-Ratios of the Column-Total Multipliers (Nonsurvey/Survey)

Texas

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's	Alpha regression 4-digit mixed LQ's	Inversion 4-digit mixed LQ's
1	1.1475	1.1501	0.9402	0.9669
2	1.2528	1.1842	.8609	.9182
3	1.3038	1.2075	1.0167	1.1266
4	1.1243	1.1263	1.0029	1.0516
5	.8573	.8781	.7848	.8043
6	.8960	.9081	.8101	.8386
7	1.0182	1.0312	.9054	.9321
8	1.2365	1.2138	1.0677	1.1101
9	1.2761	1.2665	1.1097	1.1408
10	1.1054	1.1183	.9740	.9880
11	1.3299	1.3717	1.2174	1.2259
12	1.2567	1.2767	1.0914	1.1009
13	1.1479	1.1513	.9904	.9869
14	1.2197	1.2380	1.0532	1.0553
15	1.2164	1.2350	1.0471	1.0582
16	1.2590	1.2752	1.0940	1.1100
17	1.1039	1.0956	.8913	.9155
18	1.2479	1.0409	.9251	1.1190
19	1.2135	1.0295	.7880	.8470
20	1.2507	1.1281	.7967	.8465
21	1.3613	1.3321	1.0941	1.1405
22	1.0824	1.1211	.9572	.9765
23	1.1978	1.1573	.9392	.9907
24	1.1193	1.1176	.9866	1.0179
25	1.6721	1.6525	1.4181	1.4814
26	1.4144	1.4053	1.2114	1.2258
27	1.3153	1.2760	.8846	.9161
28	1.9610	1.8959	1.4820	1.5214
29	1.5756	1.5346	1.0649	1.0782
30	.9953	1.0197	.8661	.8722

Table B1.1.-Ratios of the Column-Total Multipliers (Nonsurvey/Survey)--Continued

Texas

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's	Alpha regression 4-digit mixed LQ's	Inversion 4-digit mixed LQ's
31	1.0147	1.0724	0.8492	0.8404
32	1.3741	1.4117	1.1599	1.1604
33	1.3938	1.4028	1.0831	1.0976
34	1.4195	1.4441	1.0733	1.0926
35	1.0928	1.1223	.9980	1.0143
36	1.2688	1.2980	1.0172	1.0461
37	1.2405	1.2815	1.1025	1.1216
38	1.2696	1.2938	1.0663	1.0885
39	1.2032	1.2027	.9199	.9404
40	1.3253	1.3441	1.0894	1.1160
41	1.1742	1.1972	.9287	.9524
42	1.1261	1.1409	.9752	.9944
43	1.0769	1.1078	1.0385	1.0619
44	1.0852	1.1209	1.0695	1.0982
45	1.2553	1.2865	1.0960	1.1046
46	1.3545	1.3750	1.2227	1.2612
47	1.3765	1.4230	1.2693	1.3037
48	1.3721	1.4221	1.2796	1.3125
49	1.2437	1.2422	1.0393	1.0746
50	1.5257	1.5287	1.2812	1.3215
51	1.3206	1.3503	1.2011	1.2327
52	1.1322	1.1825	1.1009	1.1038
53	.9866	1.0009	.9050	.9430
54	.9642	.9603	.8583	.9002
55	1.3162	1.3196	1.1071	1.1454
56	1.2311	1.2367	1.0508	1.0924
57	1.7041	1.6186	1.2568	1.3473
58	1.1357	1.1497	1.0442	1.0709
59	1.2393	1.2542	1.1576	1.2011
60	1.1907	1.2062	1.1228	1.1496

Table B1.1.-Ratios of the Column-Total Multipliers (Nonsurvey/Survey)--Continued

Texas

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's	Alpha regression 4-digit mixed LQ's	Inversion 4-digit mixed LQ's
61	1.3517	1.3692	1.2172	1.2490
62	1.2734	1.2966	1.1142	1.1416
63	1.3461	1.3895	1.0609	1.0744
64	1.1800	1.1916	1.0201	1.0387
65	1.4250	1.4658	1.1082	1.1226
66	1.3881	1.4330	1.2376	1.2443
67	.9956	1.0842	.9924	.9730
68	1.2125	1.2703	1.0674	1.0596
69	1.3232	1.3648	.9918	1.0079
70	1.6143	1.6390	1.1781	1.2031
71	1.2389	1.2799	.9425	.9527
72	1.2936	1.3271	.9629	.9750
73	1.4839	1.5262	1.1731	1.1848
74	1.2591	1.2963	.9550	.9683
75	1.0953	1.1081	.9895	1.0217
76	1.4727	1.5111	1.1363	1.1535
77	1.3601	1.3840	1.0785	1.0928
78	1.5535	1.5377	1.0928	1.1102
79	1.3562	1.3547	1.0150	1.0292
80	1.3386	1.3504	1.0838	1.0981
81	1.1780	1.1890	.9033	.9167
82	1.1338	1.1381	.9036	.9194
83	1.3311	1.3451	1.0749	1.0888
84	1.4114	1.4157	1.0936	1.1109
85	1.5304	1.5127	1.1981	1.2271
86	1.3928	1.3921	.9937	.9975
87	1.9923	1.9627	1.5691	1.6121
88	1.7165	1.7212	1.3068	1.3347
89	1.7206	1.7290	1.2656	1.2966
90	1.7056	1.6679	1.3410	1.3830

Table B1.1.-Ratios of the Column-Total Multipliers (Nonsurvey/Survey)--Continued

Texas

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's	Alpha regression 4-digit mixed LQ's	Inversion 4-digit mixed LQ's
91	1.1630	1.1964	0.9720	0.9820
92	1.7952	1.7253	1.3374	1.3887
93	1.3371	1.3047	.9426	.9677
94	1.3223	1.2951	1.0249	1.0575
95	2.2570	2.2425	1.5344	1.5563
96	1.4233	1.4294	1.1464	1.1602
97	1.2217	1.2308	.9430	.9401
98	1.2242	1.2144	.9742	.9967
99	1.3415	1.3358	1.0881	1.1206
100	1.3981	1.3992	1.1353	1.1645
101	1.2964	1.3114	1.0694	1.0913
102	1.5139	1.5211	1.2301	1.2589
103	1.1155	1.0967	1.0143	1.0646
104	1.0055	1.0123	.8919	.9104
105	1.1447	1.1420	1.0218	1.0589
106	1.0201	1.0029	.9106	.9649
107	1.0078	1.0001	.8844	.9208
108	.9592	.9407	.9001	.9331
109	1.1514	1.1657	1.0328	1.0526
110	1.1886	1.1794	1.0506	1.0855
111	1.2330	1.2485	1.0322	1.0459
112	.8201	.8219	.8680	.8834
113	.7879	.8297	1.0452	1.0684
114	.7250	.7153	.6575	.6866
115	1.1375	1.1467	1.0248	1.0471
116	1.0432	1.0598	.9558	.9681
117	1.0907	1.1102	.9870	1.0038
118	.8914	.8988	.8104	.8317
119	1.3256	1.2776	1.1014	1.1692
120	1.1893	1.2066	1.1039	1.1191

Table B1.1-Ratios of the Column-Total Multipliers (Nonsurvey/Survey)--Continued

Texas

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's	Alpha regression 4-digit mixed LQ's	Inversion 4-digit mixed LQ's
121	1.0963	1.1045	0.9551	0.9718
122	1.1434	1.1585	1.0150	1.0316
123	1.1375	1.1484	1.0009	1.0215
124	.8481	.8617	.7787	.7928
125	1.2871	1.2463	1.0925	1.1489
126	1.4196	1.4202	1.1177	1.1289
127	1.0874	1.0875	.9131	.9390
128	.6327	.6336	.5724	.5902
129	1.1398	1.1469	1.0011	1.0217
130	1.0553	1.0630	.9396	.9585
131	1.2295	1.2568	1.1202	1.1283
132	1.1811	1.1946	1.0686	1.0835
133	1.0945	1.0691	.9285	.9724
Average	**1.2536**	**1.2567**	**1.0443**	**1.0709**

Table B1.2.-Ratios of the Column-Total Multipliers (Nonsurvey/Survey)

Washington

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's	Alpha regression 4-digit mixed LQ's	Inversion 4-digit mixed LQ's
1	1.2855	1.1182	0.9647	1.0415
2	1.1862	1.0459	.9179	.9863
3	1.4620	1.1101	.8750	1.0392
4	1.2613	1.1575	1.0236	1.0572
6	1.9494	1.3216	.8863	1.0640
7	1.3153	.9523	.8266	1.0135
8	1.2292	.9949	.8531	.9836
9	1.6036	1.2676	1.0877	1.2899
10	1.3139	1.1067	.9401	1.0282
11	1.3273	1.0963	.9661	1.1130
12	.9529	.8670	.7664	.8096
13	1.2805	1.1810	.9686	1.0137
14	1.3362	1.2021	1.0328	1.0824
16	1.0092	.8590	.7331	.8164
17	1.1613	.9854	.8721	.9769
18	1.2893	1.0771	.9491	1.0815
19	1.4187	1.1769	.9979	1.1438
20	1.3404	1.1422	.9607	1.0664
21	1.2625	1.0547	.9194	1.0474
22	1.3361	1.1303	.9891	1.1142
23	1.2728	1.0727	.9369	1.0599
24	1.3496	1.1640	1.0096	1.1098
25	1.2549	1.0912	.9479	1.0346
26	1.5209	1.2773	1.0708	1.1971
27	1.5060	1.3642	1.2180	1.2951
28	1.2280	1.0865	.9369	1.0013
29	1.2930	1.0896	.9330	1.0443
30	1.1367	1.0022	.8076	.8648
31	.7985	.8094	.7270	.7209
32	1.5888	1.3614	1.1918	1.3359

Table B1.2.-Ratios of the Column-Total Multipliers (Nonsurvey/Survey)--Continued

Washington

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's	Alpha regression 4-digit mixed LQ's	Inversion 4-digit mixed LQ's
33	1.4069	1.2224	0.9013	0.9672
34	1.5824	1.3773	1.0380	1.1174
35	1.3235	1.1748	.9318	.9757
36	1.3492	1.2118	.9873	1.0272
37	1.3725	1.2173	.9852	1.0385
38	1.4158	1.2603	1.0286	1.0827
39	1.6462	1.4409	1.1543	1.2230
40	1.9283	1.6752	1.2466	1.3115
41	1.2801	1.1299	.9280	.9827
42	1.4131	1.2344	1.0137	1.0867
43	1.2364	1.0993	.9599	1.0214
44	1.0199	.9284	.8045	.8379
45	1.1317	1.0358	.8702	.9033
46	1.1737	1.0641	.9331	.9720
47	1.2222	1.1262	.9835	1.0058
48	1.3347	1.1517	.9866	1.0746
49	1.2151	1.0857	.9538	1.0000
50	1.1966	1.0648	.9300	.9863
51	1.2072	1.0750	.9148	.9642
52	1.2044	.9666	.8158	.9613
Average	1.3186	1.1341	.9535	1.0394

Table B1.3.-Ratios of the Column-Total Multipliers (Nonsurvey/Survey)

West Virginia

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's	Alpha regression 4-digit mixed LQ's	Inversion 4-digit mixed LQ's
1	1.0624	1.2337	0.9247	0.9176
2	1.2722	1.4503	1.1603	1.1697
3	.9165	1.0588	.8711	.8525
4	1.1969	1.3662	1.0944	1.0918
5	.9616	1.0735	.8405	.8463
6	.9035	1.0155	.9425	.9353
7	1.2528	1.4398	1.0186	1.0221
8	1.5428	1.6649	1.2136	1.2621
9	1.0752	1.2241	.9425	.9408
10	1.1678	1.2833	.9814	1.0103
11	1.5025	1.6339	1.2175	1.2605
12	1.0781	1.2171	.8635	.8619
13	1.3755	1.5415	1.2041	1.2253
14	.9821	1.1576	.9312	.9099
15	1.2924	1.4677	1.1167	1.1217
16	1.3065	1.4718	1.1898	1.2272
17	1.4757	1.6637	1.3264	1.3486
18	1.5213	1.7032	1.3076	1.3383
19	1.2921	1.4635	1.1079	1.1164
20	1.3079	1.4627	1.1018	1.1148
21	1.4377	1.5833	1.1436	1.1660
22	2.0813	2.3619	1.7521	1.7575
23	1.7015	1.8986	1.3848	1.4026
24	1.2450	1.4668	1.1103	1.0981
25	1.0270	1.1969	.9750	.9636
26	.9991	1.1666	.9583	.9387
27	1.1469	1.3089	1.0809	1.0723
28	1.1492	1.3262	1.1043	1.0890
29	1.3687	1.5693	1.3108	1.3011
30	.6440	.7012	.6437	.6317
31	.9737	1.1548	.9334	.9073

Table B1.3.-Ratios of the Column-Total Multipliers (Nonsurvey/Survey)--Continued

West Virginia

Industry	Inversion 2-digit earnings	Original RIMS 2-digit earnings LQ's	Alpha regression 4-digit mixed LQ's	Inversion 4-digit mixed LQ's
32	1.1906	1.3901	1.1003	1.0841
33	1.1449	1.3578	1.0931	1.0620
34	1.3399	1.5386	1.2593	1.2527
35	1.4499	1.6633	1.3567	1.3718
36	1.1338	1.2902	1.0628	1.0585
37	1.0020	1.1460	.9624	.9525
38	1.0574	1.2044	.9969	1.0001
39	1.0197	1.1312	1.0004	.9923
40	.9811	1.1079	.9431	.9420
41	1.1694	1.3041	1.0483	1.0712
Average	**1.2134**	**1.3771**	**1.0872**	**1.0900**

Table B2.1.-Ratios of the Earnings Multipliers (Nonsurvey/Survey)

Texas

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's: Original formula	Original RIMS 2-digit earnings LQ's: Modified formula	Alpha regression 4-digit mixed LQ's: Original formula	Alpha regression 4-digit mixed LQ's: Modified formula	Inversion 4-digit mixed LQ's
1	1.2666	1.7416	1.3102	1.4393	1.0828	1.0920
2	1.3675	1.8290	1.3760	1.2555	.9445	.9900
3	1.0811	1.5438	1.1614	1.2521	.9420	.8995
4	.9365	1.2509	.9411	1.1071	.8329	.8731
5	.7087	.9836	.7400	.8670	.6523	.6601
6	.6671	.9258	.6965	.8121	.6110	.6181
7	.9711	1.3040	.9810	1.1536	.8679	.8937
8	1.1779	1.5319	1.1525	1.3350	1.0044	1.0565
9	1.4706	1.9421	1.4611	1.7245	1.2974	1.3376
10	.9947	1.3397	1.0079	1.1564	.8700	.8802
11	1.3399	1.8216	1.3704	1.6133	1.2138	1.2362
12	1.1831	1.6231	1.2211	1.3813	1.0392	1.0456
13	1.0057	1.3620	1.0247	1.1718	.8816	.8715
14	1.1083	1.5194	1.1431	1.2905	.9708	.9673
15	1.0448	1.4409	1.0840	1.2247	.9214	.9206
16	1.2485	1.6801	1.2640	1.4733	1.1084	1.1267
17	1.0253	1.3430	1.0104	1.1044	.8309	.8646
18	1.1315	1.5751	1.1850	1.3620	1.0247	.9708
19	1.2816	1.6088	1.2103	1.1635	.8753	.8559
20	1.3558	1.6113	1.2122	1.0507	.7905	.8411
21	1.4631	1.9435	1.4622	1.5241	1.1466	1.1825
22	.9645	1.4446	1.0868	1.1727	.8822	.8488
23	1.1993	1.6812	1.2648	1.3286	.9995	.9831
24	.9924	1.4011	1.0541	1.2132	.9127	.8914
25	2.0323	2.7590	2.0757	2.2814	1.7164	1.7441
26	1.3767	1.9253	1.4485	1.5810	1.1895	1.1370
27	1.2488	1.6513	1.2423	1.1060	.8321	.8636
28	2.1694	2.7676	2.0822	2.2133	1.6651	1.7575
29	1.5664	2.0690	1.5566	1.4018	1.0547	1.0774
30	.8191	1.1802	.8879	.9294	.6992	.6803

Table B2.1.-Ratios of the Earnings Multipliers (Nonsurvey/Survey)--Continued

Texas

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's		Alpha regression 4-digit mixed LQ's		Inversion 4-digit mixed LQ's
		Original formula	Modified formula	Original formula	Modified formula	
31	0.7789	1.2530	0.9426	0.9399	0.7071	0.6436
32	1.2987	1.8861	1.4189	1.5159	1.1405	1.1007
33	1.3667	1.8809	1.4151	1.4415	1.0845	1.0934
34	1.4264	1.9911	1.4980	1.4526	1.0929	1.1044
35	1.0741	1.5357	1.1554	1.3466	1.0131	.9998
36	1.2239	1.7176	1.2922	1.3177	.9913	1.0123
37	1.3293	1.8890	1.4211	1.6110	1.2120	1.2105
38	1.2927	1.7325	1.3034	1.4521	1.0925	1.1345
39	1.2185	1.5618	1.1750	1.1600	.8727	.9284
40	1.3178	1.7652	1.3280	1.4602	1.0985	1.1401
41	1.1321	1.5453	1.1626	1.1854	.8918	.9292
42	1.1093	1.4804	1.1137	1.2932	.9729	1.0011
43	1.2375	1.7653	1.3281	1.6370	1.2316	1.2015
44	1.1870	1.7417	1.3103	1.6425	1.2357	1.1813
45	1.4837	2.1268	1.6001	1.7752	1.3355	1.3040
46	1.6095	2.2627	1.7023	1.9983	1.5034	1.4892
47	1.5382	2.2610	1.7010	1.9777	1.4879	1.4312
48	1.8125	2.6595	2.0008	2.3691	1.7823	1.7121
49	1.1022	1.4602	1.0985	1.1934	.8978	.9422
50	1.8353	2.5043	1.8841	2.0149	1.5159	1.5469
51	1.5403	2.2128	1.6648	1.9438	1.4624	1.4224
52	1.1932	1.7249	1.2977	1.5677	1.1794	1.1362
53	1.0103	1.4453	1.0874	1.2751	.9593	.9550
54	1.0529	1.4184	1.0671	1.2430	.9352	.9711
55	1.3382	1.8189	1.3684	1.5196	1.1433	1.1643
56	1.2488	1.7419	1.3105	1.4501	1.0910	1.0893
57	1.6275	2.1497	1.6173	1.6679	1.2548	1.2905
58	1.1218	1.5100	1.1360	1.3752	1.0346	1.0551
59	1.2179	1.6563	1.2461	1.5109	1.1367	1.1741
60	1.1884	1.5891	1.1956	1.4849	1.1172	1.1360

Table B2.1.-Ratios of the Earnings Multipliers (Nonsurvey/Survey)--Continued

Texas

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's: Original formula	Original RIMS 2-digit earnings LQ's: Modified formula	Alpha regression 4-digit mixed LQ's: Original formula	Alpha regression 4-digit mixed LQ's: Modified formula	Inversion 4-digit mixed LQ's
61	1.3460	1.8289	1.3759	1.6136	1.2140	1.2389
62	1.1922	1.6355	1.2304	1.3799	1.0381	1.0645
63	1.1986	1.7120	1.2880	1.2507	.9410	.9295
64	1.1087	1.4769	1.1111	1.2763	.9602	.9854
65	1.4039	1.9667	1.4796	1.4792	1.1129	1.1182
66	1.2523	1.7931	1.3490	1.5453	1.1626	1.1155
67	.6394	1.0814	.8135	.9612	.7232	.6181
68	1.1337	1.8278	1.3751	1.4715	1.1071	.9678
69	1.4253	2.0413	1.5358	1.4221	1.0699	1.0761
70	1.5090	2.1146	1.5909	1.4387	1.0824	1.1004
71	1.1738	1.6634	1.2514	1.1927	.8973	.8984
72	1.3403	1.9199	1.4444	1.3787	1.0373	1.0287
73	1.3119	1.8365	1.3817	1.3805	1.0386	1.0445
74	1.2144	1.7362	1.3062	1.2348	.9290	.9285
75	.9269	1.2693	.9549	1.1299	.8501	.8585
76	1.5114	2.1568	1.6226	1.5557	1.1704	1.1684
77	1.2743	1.7483	1.3153	1.3447	1.0116	1.0253
78	1.4638	1.9394	1.4591	1.3364	1.0054	1.0307
79	1.1722	1.5609	1.1743	1.1454	.8617	.8826
80	1.3727	1.8351	1.3806	1.4750	1.1097	1.1351
81	.8494	1.1442	.8608	.8667	.6521	.6666
82	.9064	1.1993	.9022	.9683	.7285	.7483
83	1.3022	1.7586	1.3231	1.4037	1.0560	1.0694
84	1.4196	1.8867	1.4194	1.4639	1.1013	1.1300
85	1.5043	1.9597	1.4743	1.5407	1.1591	1.2044
86	1.3787	1.8900	1.4219	1.2400	.9329	.9215
87	2.9025	3.7285	2.8051	3.0497	2.2944	2.4073
88	1.8394	2.4614	1.8518	1.8800	1.4144	1.4531
89	1.7336	2.3603	1.7757	1.6695	1.2560	1.2872
90	1.7389	2.2061	1.6597	1.8153	1.3657	1.4401

Table B2.1.-Ratios of the Earnings Multipliers (Nonsurvey/Survey)--Continued

Texas

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's: Original formula	Original RIMS 2-digit earnings LQ's: Modified formula	Alpha regression 4-digit mixed LQ's: Original formula	Alpha regression 4-digit mixed LQ's: Modified formula	Inversion 4-digit mixed LQ's
91	1.1373	1.6136	1.2139	1.3031	0.9803	0.9628
92	1.7992	2.2426	1.6872	1.7646	1.3276	1.4161
93	1.1109	1.4245	1.0717	1.0409	.7831	.8133
94	1.1045	1.4181	1.0669	1.1364	.8549	.8978
95	3.3040	4.4360	3.3373	2.9320	2.2059	2.2545
96	1.3583	1.8217	1.3705	1.5004	1.1288	1.1455
97	1.0504	1.4790	1.1127	1.0903	.8203	.7962
98	1.1580	1.5069	1.1337	1.2203	.9180	.9547
99	1.4395	1.9190	1.4437	1.5491	1.1654	1.2035
100	1.3373	1.7631	1.3264	1.4336	1.0785	1.1222
101	1.2464	1.7045	1.2823	1.3813	1.0392	1.0544
102	1.3825	1.8755	1.4110	1.4932	1.1234	1.1469
103	.9787	.2478	.9387	1.1611	.8736	.9469
104	.8687	1.1533	.8676	1.0236	.7701	.7921
105	1.1517	1.4857	1.1178	1.3486	1.0146	1.0799
106	.7816	1.0104	.7601	.9136	.6873	.7394
107	.8590	1.1241	.8457	.9970	.7501	.7880
108	.7714	.9653	.7263	.9015	.6782	.7229
109	1.2160	1.6039	1.2066	1.4496	1.0906	1.1304
110	1.1725	1.5067	1.1335	1.3361	1.0052	1.0668
111	1.0865	1.4453	1.0873	1.1933	.8978	.9221
112	.5710	.7674	.5774	.8383	.6307	.6021
113	.7317	1.0757	.8093	1.4796	1.1132	.9679
114	.5584	.7079	.5326	.6436	.4842	.5261
115	1.0447	1.3760	1.0352	1.2435	.9355	.9710
116	.9901	1.3148	.9892	1.2029	.9050	.9266
117	.9086	1.1963	.9000	1.0734	.8076	.8425
118	.8275	1.0814	.8135	.9766	.7347	.7738
119	1.1770	1.4554	1.0949	1.2658	.9523	1.0457
120	1.1669	1.5424	1.1604	1.4117	1.0621	1.0936

Table B2.1.-Ratios of the Earnings Multipliers (Nonsurvey/Survey)--Continued

Texas

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's: Original formula	Original RIMS 2-digit earnings LQ's: Modified formula	Alpha regression 4-digit mixed LQ's: Original formula	Alpha regression 4-digit mixed LQ's: Modified formula	Inversion 4-digit mixed LQ's
121	0.9292	1.2302	0.9255	1.0691	0.8043	0.8317
122	1.0341	1.3704	1.0310	1.2162	.9150	.9455
123	1.2146	1.6010	1.2045	1.4212	1.0692	1.1095
124	.6175	.8202	.6171	.7405	.5571	.5782
125	1.2555	1.7021	1.2805	1.5002	1.1286	1.1270
126	1.6820	2.2435	1.6879	1.7613	1.3251	1.3524
127	.8538	1.1215	.8437	.9371	.7050	.7363
128	.3664	.4785	.3600	.4214	.3170	.3383
129	.9613	1.2773	.9609	1.1400	.8577	.8795
130	1.0643	1.4190	1.0676	1.2714	.9565	.9776
131	1.0544	1.4055	1.0574	1.2825	.9649	.9845
132	1.1628	1.5343	1.1543	1.4003	1.0535	1.0812
133	.9738	.4497	.3383	.3644	.2742	.9191
Average	**1.2264**	**1.6522**	**1.2486**	**1.3628**	**1.0252**	**1.0434**

Table B2.2.-Ratios of the Value-Added Multipliers (Nonsurvey/Survey)

Washington

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's		Alpha regression 4-digit mixed LQ's		Inversion 4-digit mixed LQ's
		Original formula	Modified formula	Original formula	Modified formula	
1	1.1472	1.5115	0.9689	1.3047	0.8363	0.9429
2	.9937	1.3256	.8497	1.1636	.7459	.8365
3	1.3713	1.5960	1.0231	1.1987	.7684	.9522
4	1.2608	1.7517	1.1229	1.5661	1.0039	1.0857
6	1.9647	2.1649	1.3877	1.2690	.8135	.9330
7	1.3387	1.5658	1.0037	1.3222	.8476	.9926
8	1.0797	1.3147	.8428	1.0984	.7041	.8505
9	1.5995	1.9016	1.2190	1.5809	1.0134	1.2595
10	1.2094	1.5622	1.0014	1.3075	.8381	.9404
11	1.2426	1.5746	1.0093	1.3676	.8767	1.0332
12	.7146	.9684	.6208	.8304	.5323	.5933
13	1.1186	1.5672	1.0046	1.2370	.7930	.8703
14	1.2343	1.6860	1.0807	1.4542	.9332	1.0188
16	.8427	1.0633	.6816	.8836	.5664	.6747
17	1.0226	1.3506	.8658	1.1831	.7584	.8544
18	1.1634	1.5106	.9683	1.3148	.8428	.9675
19	1.3397	1.7053	1.0931	1.4134	.9060	1.0654
20	1.1789	1.5378	.9857	1.2733	.8162	.9343
21	1.1755	1.5033	.9637	1.2859	.8243	.9620
22	1.2179	1.5764	1.0105	1.3571	.8700	1.0044
23	1.1478	1.4886	.9542	1.2807	.8210	.9459
24	1.1565	1.5175	.9728	1.3108	.8403	.9557
25	1.0717	1.4193	.9098	1.2225	.7836	.8844
26	1.3737	1.7508	1.1223	1.4365	.9209	1.0701
27	1.7556	2.3745	1.5221	2.0333	1.3034	1.4504
28	1.0837	1.4705	.9426	1.2699	.8140	.8960
29	1.2076	1.5381	.9859	1.3017	.8344	.9737
30	.9092	1.2186	.7811	.9540	.6115	.6845
31	.3760	.7639	.4897	.6461	.4141	.3089

Table B2.2.-Ratios of the Value-Added Multipliers (Nonsurvey/Survey)--Continued

Washington

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's		Alpha regression 4-digit mixed LQ's		Inversion 4-digit mixed LQ's
		Original formula	Modified formula	Original formula	Modified formula	
32	1.6165	2.1532	1.3803	1.8436	1.1818	1.3305
33	1.2653	1.6984	1.0887	1.2076	.7741	.8605
34	1.4631	1.9678	1.2614	1.4398	.9230	1.0258
35	1.2155	1.6465	1.0554	1.2823	.8220	.8975
36	1.2497	1.7175	1.1010	1.3986	.8965	.9692
37	1.2706	1.7173	1.1008	1.3755	.8817	.9684
38	1.3217	1.7953	1.1508	1.4522	.9309	1.0200
39	1.5567	2.0713	1.3278	1.6324	1.0464	1.1565
40	2.1471	2.8898	1.8524	2.0597	1.3203	1.4328
41	1.0593	1.4318	.9178	1.1595	.7433	.8150
42	1.2417	1.6619	1.0653	1.3494	.8650	.9601
43	1.0817	1.4558	.9332	1.2732	.8162	.9063
44	.9219	1.2793	.8200	1.1084	.7105	.7661
45	1.1571	1.6443	1.0541	1.3512	.8662	.9137
46	1.0292	1.4176	.9087	1.2548	.8044	.8737
47	1.0965	1.5336	.9831	1.3572	.8700	.9296
48	1.2629	1.6664	1.0682	1.4139	.9064	1.0206
49	1.0587	1.4454	.9265	1.2807	.8209	.8928
50	1.0945	1.4668	.9403	1.2910	.8276	.9227
51	1.0508	1.4193	.9098	1.2151	.7789	.8595
52	1.0544	.4949	.3172	.3702	.2373	.9310
Average	**1.2103**	**1.5770**	**1.0109**	**1.2996**	**.8331**	**.9479**

Table B2.3.-Ratios of the Earnings Multipliers (Nonsurvey/Survey)

West Virginia

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's: Original formula	Original RIMS 2-digit earnings LQ's: Modified formula	Alpha regression 4-digit mixed LQ's: Original formula	Alpha regression 4-digit mixed LQ's: Modified formula	Inversion 4-digit mixed LQ's
1	1.1890	1.8695	1.4065	1.3904	1.0460	1.0588
2	1.4520	2.1502	1.6177	1.7482	1.3152	1.3625
3	.9347	1.5017	1.1298	1.2040	.9058	.8662
4	1.2240	1.8683	1.4056	1.4952	1.1249	1.1336
5	1.0892	1.7199	1.2940	1.2128	.9124	.9487
6	.7670	1.2107	.9108	1.1033	.8300	.8160
7	1.4135	2.2596	1.7000	1.5237	1.1463	1.1802
8	1.6202	2.3388	1.7596	1.5878	1.1946	1.2966
9	.8138	1.2240	.9209	.9322	.7013	.7196
10	1.0927	1.5622	1.1753	1.2038	.9057	.9620
11	1.8542	2.6837	2.0190	1.9243	1.4477	1.5519
12	1.1992	1.7856	1.3433	1.2700	.9555	.9830
13	1.5345	2.4122	1.8148	1.8219	1.3707	1.3640
14	.9021	1.6716	1.2576	1.2303	.9256	.8169
15	1.2127	1.8178	1.3676	1.3996	1.0530	1.0775
16	1.2755	1.9090	1.4362	1.5311	1.1519	1.2127
17	1.5119	2.2653	1.7043	1.7867	1.3442	1.3933
18	1.5953	2.3805	1.7909	1.8142	1.3649	1.4174
19	1.1803	1.7455	1.3132	1.3492	1.0150	1.0452
20	1.5194	2.2597	1.7000	1.6816	1.2651	1.3069
21	1.4055	2.0838	1.5677	1.4463	1.0881	1.1324
22	4.9701	7.3374	5.5201	5.5863	4.2027	4.3250
23	2.2614	3.4142	2.5686	2.4406	1.8361	1.8837
24	1.4014	2.2170	1.6679	1.6978	1.2773	1.2851
25	.9273	1.3773	1.0362	1.1632	.8751	.8913
26	.9811	1.4902	1.1211	1.2568	.9455	.9394
27	1.2496	1.8600	1.3993	1.5473	1.1641	1.1834
28	.8832	1.4434	1.0859	1.1009	.8282	.8183
29	1.8912	2.9389	2.2110	2.3857	1.7948	1.8009

Table B2.3.-Ratios of the Earnings Multipliers (Nonsurvey/Survey)--Continued

West Virginia

Industry	Inversion 2-digit earnings LQ's	Original RIMS 2-digit earnings LQ's		Alpha regression 4-digit mixed LQ's		Inversion 4-digit mixed LQ's
		Original formula	Modified formula	Original formula	Modified formula	
30	0.2254	0.4089	0.3076	0.3253	0.2447	0.2137
31	.9302	1.4567	1.0959	1.2046	.9062	.8833
32	1.2175	1.8279	1.3752	1.5045	1.1319	1.1426
33	1.1138	1.7119	1.2879	1.4300	1.0759	1.0580
34	1.5305	2.2984	1.7291	1.9106	1.4374	1.4582
35	1.7537	2.5574	1.9240	2.1365	1.6074	1.6985
36	1.1186	1.7374	1.3071	1.3995	1.0529	1.0515
37	.9035	1.3449	1.0118	1.1428	.8598	.8708
38	.8951	1.4790	1.1127	1.1567	.8702	.8450
39	.9003	1.4773	1.1115	1.1966	.9003	.8642
40	1.0112	1.5151	1.1399	1.2733	.9579	.9803
41	1.0584	.3764	.2832	.2509	.1887	1.0314
Average	**1.3173**	**1.9753**	**1.4861**	**1.5308**	**1.1517**	**1.1920**

Table B3.1.-Chi-Square Statistics

Texas

Industry	Inversion 2-digit earnings LQ's	Inversion 4-digit mixed LQ's
1	0.3955	0.2071
2	.3159	.1616
3	.3018	.1877
4	.5560	.3904
5	.5957	.4765
6	.4626	.3418
7	.4262	.2190
8	.5984	.4263
9	.6381	.3803
10	.3849	.2085
11	.8264	.4093
12	.4014	.2117
13	.3518	.1544
14	.4439	.2455
15	.3874	.1512
16	.3849	.1588
17	.4163	.1446
18	.2503	.1263
19	.2588	.1119
20	.3431	.2077
21	.3182	.1670
22	.3241	.1517
23	.3320	.1937
24	.3302	.1246
25	.6061	.2858
26	.4066	.1895
27	.3174	.2029
28	.6999	.1545
29	3.5579	.4537
30	1.1892	.5891
31	.5360	.2984

Table B3.1.-Chi-Square Statistics--Continued

Texas

Industry	Inversion 2-digit earnings LQ's	Inversion 4-digit mixed LQ's
32	0.5057	0.1460
33	.4717	.1716
34	.8774	.4516
35	.5744	.2148
36	.4679	.2651
37	.3394	.1225
38	.3645	.1696
39	.5206	.3621
40	.4593	.1994
41	.2581	.0973
42	.3435	.1736
43	.5179	.2605
44	.3926	.2170
45	2.1069	1.2711
46	.7884	.4589
47	.6223	.2739
48	.6195	.2746
49	.3525	.1215
50	.6446	.3669
51	.4679	.2052
52	.3157	.1375
53	.4800	.2203
54	1.0194	.2749
55	.3846	.1543
56	.8289	.1441
57	.9016	.3615
58	.4328	.1903
59	.4120	.1630
60	.4250	.1320
61	.8505	.4401

Table B3.1.-Chi-Square Statistics--Continued

Texas

Industry	Inversion 2-digit earnings LQ's	Inversion 4-digit mixed LQ's
62	0.6045	0.2568
63	.7933	.4137
64	.6770	.2382
65	.6503	.1692
66	.5194	.2631
67	.6906	.5359
68	.3688	.1583
69	.4724	.2457
70	2.5080	.5218
71	.7824	.2155
72	.3516	.1886
73	1.2706	.3531
74	1.3249	.3719
75	.3572	.1680
76	.6573	.2069
77	.5323	.1580
78	1.1836	.3709
79	.3572	.1302
80	.3751	.1385
81	.7524	.2054
82	.7194	.1550
83	.4199	.1641
84	.5559	.1882
85	.7273	.2453
86	1.1470	.2240
87	1.7251	.5282
88	.6047	.1748
89	4.9354	1.1786
90	.4821	.1841
91	.3850	.2010

Table B3.1.-Chi-Square Statistics--Continued

Texas

Industry	Inversion 2-digit earnings LQ's	Inversion 4-digit earnings LQ's
92	0.5969	0.2105
93	1.5153	.3476
94	1.5259	.7521
95	2.5646	.5995
96	.7144	.1687
97	.5920	.1815
98	.3810	.1934
99	2.2790	.5718
100	.8888	.3166
101	.3604	.1630
102	.9035	.3662
103	.7740	.6092
104	.7540	.4355
105	.8103	.6055
106	.4061	.2484
107	.3589	.1057
108	.3807	.1632
109	.4946	.1759
110	.5385	.2318
111	1.9417	.9271
112	.6424	.5387
113	.4184	.2864
114	.3977	.3244
115	.3681	.1728
116	.3345	.1282
117	.4228	.1640
118	.4287	.2126
119	.3936	.1427
120	.5421	.2699
121	.4365	.1601

Table B3.1.-Chi-Square Statistics--Continued

Texas

Industry	Inversion 2-digit earnings LQ's	Inversion 4-digit mixed LQ's
122	0.4676	0.2078
123	.6572	.3151
124	.3652	.2129
125	.3683	.1456
126	1.5403	.6604
127	.4077	.1931
128	.4067	.3248
129	.3770	.2090
130	.4117	.1554
131	.5777	.3158
132	.4384	.1931
133	.6284	.1966
Average	.6906	.2799

Table B3.2.-CHI-Square Statistics

Washington

Industry	Inversion 2-digit earnings LQ's	Inversion 4-digit mixed LQ's
1	0.4578	0.1804
2	.5162	.1383
3	.3855	.1099
4	.4488	.0866
6	.4224	.0569
7	.3943	.0754
8	.3313	.1303
9	.4705	.1397
10	.4772	.0919
11	.4266	.0925
12	.9475	.3293
13	.5556	.1721
14	.6761	.1643
16	1.2263	.1831
17	.5702	.0755
18	.5253	.0829
19	.9849	.1640
20	.8477	.1639
21	.5316	.1509
22	.4361	.1028
23	.4811	.0985
24	.6368	.1781
25	.5005	.1285
26	.5026	.1292
27	.9921	.6002
28	.9055	.2929
29	.6787	.1458
30	.4978	.1851
31	.4400	.4581
32	.9507	.4749
.33	.5427	.1169

Table B3.2.-Chi-Square Statistics--Continued

Washington

Industry	Inversion 2-digit earnings LQ's	Inversion 4-digit mixed LQ's
34	0.7185	0.1719
35	.2578	.0556
36	.6013	.1154
37	.5555	.1206
38	.3175	.1008
39	1.3397	.5940
40	.5937	.2363
41	.7599	.1899
42	.8428	.2081
43	.5186	.1314
44	.6199	.2414
45	.6789	.2205
46	.6328	.1790
47	.5208	.0965
48	.4598	.0782
49	.5276	.0998
50	.4704	.0536
51	.9469	.1242
52	.6753	.0733
Average	**.6160**	**.1718**

Table B3.3.-Chi-Square Statistics

West Virginia

Industry	Inversion 2-digit earnings LQ's	Inversion 4-digit mixed LQ's
1	0.5871	0.1107
2	.5894	.2797
3	1.3830	.5515
4	.7893	.4024
5	.7777	.2035
6	1.2656	.1377
7	.6669	.2152
8	5.3096	2.2861
9	.3641	.1858
10	.6150	.2418
11	1.6027	.8022
12	5.5798	.2675
13	.5945	.1942
14	.9327	.9026
15	.6303	.2838
16	.2834	.1502
17	.5251	.2661
18	.5516	.2521
19	.5592	.1830
20	.8766	.2256
21	1.7211	.3910
22	5.2890	2.0730
23	.8789	.5279
24	.4655	.1539
25	.3249	.1115
26	.2446	.0841
27	.3638	.1179
28	.5292	.2548
29	.7627	.3468
30	.3898	.3807
31	.5198	.2138

Table B3.3.-Chi-Square Statistics--Continued

West Virginia

Industry	Inversion 2-digit earnings LQ's	Inversion 4-digit mixed LQ's
32	0.8751	0.2046
33	.5444	.2378
34	.4114	.1842
35	.6056	.2194
36	.4702	.2067
37	.2140	.0842
38	.6958	.3377
39	.1791	.0916
40	.3340	.1588
41	.4985	.1707
Average	**.9951**	**.3584**

Appendix C

ESTIMATES OF LPW IMPACTS

Table C1.1.-Industry Designations for LPW Impact Application

Industry number Column	Industry number Row	Industry name	1972 I-O code	1972 SIC
1	1	Agriculture products and services and forestry and fishery services	010100-020702, 040000	01-02,07 (excl. 074),085,092
2	2	Forestry and fishery products	030000	081-4,091,097
3	3	Coal mining	070000	1111, pt. 1112,1211, pt. 1212
4	4	Crude petroleum and natural gas	080000	131-1, pt. 133
5	5	Other mining	050000,060100, 060200,090000, 100000	101-106, pt. 108, 109,141-5, pt.148, 149,147
- - -	6	New construction	110101-110508	pt. 15-17, pt. 138, pt. 1112, pt. 1213, pt. 148, pt. 108
- - -	7	Maintenance and repair construction	120100-120216	pt. 15-17, pt. 138
8	8	Food and kindred products and tobacco	140101-150200	20-21
9	9	Textile mill products	160100-180300	221-9
10	10	Apparel	180400-190306	231-9,39996
11	11	Paper and allied products	240100-25000	261-5
12	12	Printing and publishing	260100-26085	27
13	13	Chemicals and refined petroleum	270100-310300	28-9
14	14	Rubber and leather products	320100-340305	301-19
15	15	Lumber and furniture products	200100-230700	241-59 (excl. 2451)
16	16	Stone, clay, and glass products	350100-362200	321-9
17	17	Primary metals	370101-381400	331-9,3462-3,28195
18	18	Fabricated metals	390100-42110, 130200,130500-130700	341-9, (excl. 3462-3)
19	19	Nonelectrical machinery	430100-520500	35
20	20	Electrical machinery	530100-580500	36,3825

Table C1.1.-Industry Designations for LPW Impact Application--Continued

Industry number: Column	Industry number: Row	Industry name	1972 I-O code	1972 SIC
21	21	Motor vehicles and equipment	590100-590302	371
22	22	Other transportation equipment	600100-610700, 130100,130300	372-9.2451
23	23	Instruments	620100-630300	38 (excl. 3825)
24	24	Miscellaneous manufacturing	640101-641200	39 (excl. 39996)
25	25	Transportation, local government transit, and postal	650100-650700, 780100,790100	40-7
26	26	Communication	660000,67000	48
27	27	Utilities	680100-680300, 780200,790200	491-7
28	28	Wholesale trade	690100	50,51 (excl. manufacturers' sales offices)
29	29	Retail trade	690200	52-7,59,7396, 8042
30	30	Eating and drinking establishments	740000	58, pt. 70
31	31	Finance	700100-700300	60,62 (excl. 613), 67
32	32	Insurance	700400,700500	63,64
33	33	Real estate	710200	65-6, pt. 1531
34	34	Lodging and amusements	720100,760100, 760200	70 (excl. dining) 78,79
35	35	Personal services	720200,720300	72-4 (excl. 7396), 762-4, pt. 7699
36	36	Business services	730100-730300	73 (excl. 7396), 7692,7694, pt. 7699 81,89 (excl. 8922)
37	37	Health services	770100-770300	801-3,8041 074,8049,805-9
38	38	Other services	750000,770400-770900	75,82-86,8922 074,8049,805-9

Table C1.1.-Industry Designations for LPW Impact Application--Continued

Industry number Column	Row	Industry name	1972 I-O code	1972 SIC
39	39	Households	840000	- - -
40	6	New residential 1-unit structures, nonfarm	110101	pt. 15, pt. 17
41	6	New residential 2-4 unit structures, nonfarm	110102	pt. 15, pt. 17
42	6	New residential garden apartments	110103	pt. 15-17
43	6	New residential high-rise apartments	110104	pt. 15-17
44	6	New residential additions and alterations, nonfarm	110105	pt. 15. pt. 17
45	6	New hotels and motels	110106	pt. 15-17
46	6	New dormitories	110107	pt. 15, pt. 17
47	6	New industrial buildings	110201	pt. 15-17
48	6	New office buildings	110202	pt. 15, pt. 17
49	6	New warehouses	110203	pt. 15, pt. 17
50	6	New garages and service stations	110204	pt. 15, pt. 17
51	6	New stores and restaurants	110205	pt. 15, pt. 17
52	6	New religious buildings	110206	pt. 15, pt. 17
53	6	New educational buildings	110207	pt. 15, pt. 17
54	6	New hospital and institutional buildings	110208	pt. 15, pt. 17
55	6	New other nonfarm buildings	110209	pt. 15, pt. 17
56	6	New telephone and telegraph facilities	110301	pt. 16, pt. 17
57	6	New railroads	110302	pt. 16, pt. 17
58	6	New electric utility facilities	110303	pt. 16, pt. 17
59	6	New gas utility facilities	110304	pt. 16, pt. 17
60	6	New petroleum pipelines	110305	pt. 16, pt. 17

Table C1.1.-Industry Designations for LPW Impact Application--Continued

Industry number Column	Row	Industry name	1972 I-O code	1972 SIC
61	6	New water supply facilities	110306	pt. 16, pt. 17
62	6	New sewer system facilities	110307	pt. 16, pt. 17
63	6	New local transit facilities	110308	pt. 16, pt. 17
64	6	New highways and streets	110400	pt. 16, pt. 17
65	6	New farm housing units and additions	110501	pt. 15, pt. 17
66	6	New farm service facilities	110502	pt. 15, pt. 17
67	6	New petroleum and natural gas well drilling	110503	pt. 138
68	6	New petroleum, natural gas, and solid mineral exploration	110504	pt. 138 1213, pt. 138, pt. 148
69	6	New military facilities	110505	pt. 15-17
70	6	New conservation and development facilities	110506	pt. 15-17
71	6	Other new nonbuilding facilities	110507	pt. 15-17
72	6	New access structures for solid mineral development	110508	pt. 108, pt. 112, pt. 1213, pt. 148
73	7	Maintenance and repair, residential	120100	pt. 15, pt. 17
74	7	Maintenance and repair of other nonfarm buildings	120201	pt. 15, pt. 17
75	7	Maintenance and repair of farm residential buildings	120202	pt. 15, pt. 17
76	7	Maintenance and repair of farm service facilities	120203	pt. 15, pt. 17
77	7	Maintenance and repair of telephone and telegraph facilities	120204	pt. 16, pt. 17
78	7	Maintenance and repair of railroads	120205	pt. 16, pt. 17
79	7	Maintenance and repair of electric utility facilities	120206	pt. 16, pt. 17

Table C1.1.-Industry Designations for LPW Impact Application--Continued

Industry number Column	Row	Industry name	1972 I-O code	1972 SIC
80	7	Maintenance and repair of gas utility facilities	120207	pt. 16, pt. 17
81	7	Maintenance and repair of petroleum pipelines	120208	pt. 16, pt. 17
82	7	Maintenance and repair of water supply facilities	120209	pt. 16, pt. 17
83	7	Maintenance and repair of sewer facilities	120210	pt. 16, pt. 17
84	7	Maintenance and repair of local transit facilities	120211	pt. 16, pt. 17
85	7	Maintenance and repair of military facilities	120212	pt. 16, pt. 17
86	7	Maintenance and repair of conservation and development facilities	120213	pt. 15-17
87	7	Maintenance and repair of highways and streets	120214	pt. 16, pt. 17
88	7	Maintenance and repair of petroleum and natural gas wells	120215	pt. 138
89	7	Maintenance and repair of other nonbuilding facilities	120216	pt. 15-17

Table C2.1.-RIMS II Multipliers--New Warehouses (49)

	Industry	United States	Denver, Colorado	Detroit, Michigan	Wilmington, North Carolina
1	Agriculture	0.078	0.006	0.005	0.007
2	Forestry and fisheries	.003	0	0	.001
3	Coal mining	.007	.001	0	0
4	Petroleum and natural gas	.026	.005	0	0
5	Other mining	.021	.009	.003	.010
6	New construction	1.000	1.000	1.000	1.000
7	Maintenance and repair	.035	.018	.018	.013
8	Food and kindred products	.132	.050	.034	.009
9	Textiles	.030	0	.001	.007
10	Apparel	.028	.004	.002	.013
11	Paper	.035	.004	.002	.001
12	Printing	.035	.019	.009	.004
13	Chemicals	.135	.040	.044	.010
14	Rubber and leather products	.035	.005	.015	0
15	Lumber and furniture	.039	.010	.005	.005
16	Stone, clay, and glass	.080	.055	.031	.034
17	Primary metals	.147	.004	.084	.002
18	Fabricated metals	.234	.157	.169	.045
19	Nonelectrical machinery	.046	.008	.015	.001
20	Electrical machinery	.055	.005	.006	.001
21	Motor vehicles	.044	0	.032	0
22	Other transportation equipment	.008	0	.002	.001
23	Instruments	.011	.003	.001	0
24	Miscellaneous	.012	.003	.003	0
25	Transportation	.129	.077	.071	.066
26	Communication	.042	.026	.020	.019
27	Utilities	.067	.028	.037	.025
28	Wholesale trade	.138	.088	.075	.054
29	Retail trade	.142	.104	.096	.086
30	Eating and drinking establishments	.061	.042	.035	.031
31	Finance	.047	.031	.021	.013
32	Insurance	.045	.030	.029	.009
33	Real estate	.115	.070	.043	.050
34	Lodging and amusements	.024	.015	.010	.008
35	Personal services	.024	.015	.015	.006
36	Business services	.143	.112	.107	.063
37	Health services	.052	.019	.036	.015
38	Other services	.075	.047	.039	.026
39	Household	1.006	.704	.723	.540
Total		**4.448**	**2.815**	**2.839**	**2.175**

Table C2.2.-RIMS II Multipliers--New Other Nonfarm Buildings (55)

	Industry	United States	Denver, Colorado	Detroit, Michigan	Wilimington, North Carolina
1	Agriculture	0.077	0.005	0.003	0.005
2	Forestry and fisheries	.004	0	0	.001
3	Coal mining	.007	.001	0	0
4	Petroleum and natural gas	.021	.003	0	0
5	Other mining	.019	.007	.002	.008
6	New construction	1.000	1.000	1.000	1.000
7	Maintenance and repair	.034	.018	.017	.014
8	Food and kindred products	.133	.051	.034	.009
9	Textiles	.034	0	.001	.007
10	Apparel	.029	.004	.002	.012
11	Paper	.036	.003	.002	.001
12	Printing	.034	.018	.009	.004
13	Chemicals	.104	.020	.023	.009
14	Rubber and leather products	.038	.006	.017	0
15	Lumber and furniture	.072	.026	.017	.006
16	Stone, clay, and glass	.103	.073	.040	.044
17	Primary metals	.128	.004	.068	.001
18	Fabricated metals	.146	.087	.102	.002
19	Nonelectrical machinery	.065	.017	.023	.001
20	Electrical machinery	.065	.006	.008	.001
21	Motor vehicles	.045	0	.032	0
22	Other transportation equipment	.007	0	.002	.001
23	Instruments	.014	.003	.001	0
24	Miscellaneous	.012	.003	.003	0
25	Transportation	.119	.067	.059	.054
26	Communication	.043	.027	.020	.019
27	Utilities	.066	.027	.036	.026
28	Wholesale trade	.139	.089	.075	.054
29	Retail trade	.138	.100	.091	.082
30	Eating and drinking establishments	.063	.042	.035	.031
31	Finance	.048	.032	.022	.013
32	Insurance	.045	.030	.028	.009
33	Real estate	.117	.072	.044	.051
34	Lodging and amusements	.025	.015	.010	.008
35	Personal services	.024	.015	.015	.006
36	Business services	.178	.147	.142	.085
37	Health services	.052	.019	.035	.015
38	Other services	.076	.047	.039	.026
39	Household	1.074	.710	.715	.538
Total		**4.435**	**2.796**	**2.773**	**2.143**

Table C2.3.-RIMS II Multipliers--New Sewer System Facilities (62)

	Industry	United States	Denver, Colorado	Detroit, Michigan	Wilmington, North, Carolina
1	Agriculture	0.071	0.006	0.004	0.008
2	Forestry and fisheries	.002	0	0	.001
3	Coal mining	.008	.001	0	0
4	Petroleum and natural gas	.020	.003	0	0
5	Other mining	.031	.015	.005	.017
6	New construction	1.000	1.000	1.000	1.000
7	Maintenance and repair	.031	.016	.016	.014
8	Food and kindred products	.117	.046	.030	.008
9	Textiles	.027	0	.001	.007
10	Apparel	.025	.004	.002	.011
11	Paper	.031	.003	.002	.001
12	Printing	.029	.015	.007	.003
13	Chemicals	.094	.019	.022	.011
14	Rubber and leather products	.031	.004	.013	0
15	Lumber and furniture	.023	.003	.002	.003
16	Stone, clay, and glass	.158	.114	.070	.086
17	Primary metals	.186	.044	.133	.012
18	Fabricated metals	.078	.043	.050	.002
19	Nonelectrical machinery	.080	.045	.024	.001
20	Electrical machinery	.041	.005	.006	.001
21	Motor vehicles	.042	0	.030	0
22	Other transportation equipment	.007	0	.002	.001
23	Instruments	.011	.005	.003	0
24	Miscellaneous	.011	.003	.003	0
25	Transportation	.111	.063	.057	.053
26	Communication	.037	.023	.017	.016
27	Utilities	.063	.027	.035	.028
28	Wholesale trade	.133	.090	.074	.056
29	Retail trade	.113	.081	.072	.064
30	Eating and drinking establishments	.054	.037	.030	.027
31	Finance	.042	.028	.019	.012
32	Insurance	.045	.031	.029	.010
33	Real estate	.101	.061	.036	.043
34	Lodging and amusements	.021	.013	.008	.007
35	Personal services	.021	.014	.013	.005
36	Business services	.106	.078	.073	.045
37	Health services	.046	.018	.031	.014
38	Other services	.070	.045	.037	.026
39	Household	.953	.646	.633	.490
Total		**4.069**	**2.650**	**2.587**	**2.082**

Table C2.4.-RIMS II Multipliers--New Highways and Streets (64)

Industry	United States	Denver, Colorado	Detroit, Michigan	Wilmington, North Carolina
1 Agriculture	0.066	0.005	0.003	0.006
2 Forestry and fisheries	.002	0	0	.001
3 Coal mining	.006	.001	0	0
4 Petroleum and natural gas	.032	.007	0	0
5 Other mining	.056	.037	.014	.047
6 New construction	1.000	1.000	1.000	1.000
7 Maintenance and repair	.031	.017	.016	.015
8 Food and kindred products	.113	.046	.029	.008
9 Textiles	.025	0	0	.007
10 Apparel	.024	.004	.002	.012
11 Paper	.031	.003	.002	.001
12 Printing	.030	.015	.008	.004
13 Chemicals	.169	.051	.060	.016
14 Rubber and leather products	.027	.003	.010	0
15 Lumber and furniture	.023	.002	.001	.003
16 Stone, clay, and glass	.148	.135	.075	.104
17 Primary metals	.077	.002	.045	.001
18 Fabricated metals	.093	.059	.070	.001
19 Nonelectrical machinery	.025	.004	.007	.001
20 Electrical machinery	.032	.002	.002	.001
21 Motor vehicles	.038	0	.028	0
22 Other transportation equipment	.006	0	.001	.001
23 Instruments	.006	.002	0	0
24 Miscellaneous	.015	.007	.007	0
25 Transportation	.128	.083	.072	.077
26 Communication	.035	.022	.016	.016
27 Utilities	.061	.027	.032	.031
28 Wholesale trade	.133	.096	.078	.063
29 Retail trade	.116	.087	.077	.073
30 Eating and drinking establishments	.050	.035	.028	.026
31 Finance	.039	.027	.017	.012
32 Insurance	.041	.029	.027	.009
33 Real estate	.099	.061	.034	.044
34 Lodging and amusements	.020	.013	.008	.008
35 Personal services	.020	.013	.013	.005
36 Business services	.102	.076	.070	.044
37 Health services	.044	.018	.031	.015
38 Other services	.068	.046	.037	.028
39 Household	.918	.644	.619	.514
Total	**3.950**	**2.680**	**2.539**	**2.195**

Table C2.5.-RIMS II Multipliers--New Construction and Development Facilities (70)

	Industry	United States	Denver, Colorado	Detroit, Michigan	Wilmington, North Carolina
1	Agriculture	0.068	0.005	0.003	0.006
2	Forestry and fisheries	.002	0	0	.001
3	Coal mining	.006	.001	0	0
4	Petroleum and natural gas	.025	.004	0	0
5	Other mining	.026	.014	.005	.018
6	New construction	1.000	1.000	1.000	1.000
7	Maintenance and repair	.029	.016	.015	.013
8	Food and kindred products	.119	.049	.032	.010
9	Textiles	.026	0	0	.008
10	Apparel	.026	.004	.002	.014
11	Paper	.027	.002	.002	.001
12	Printing	.029	.015	.007	.004
13	Chemicals	.124	.026	.026	.010
14	Rubber and leather products	.032	.005	.013	0
15	Lumber and furniture	.029	.006	.001	.010
16	Stone, clay, and glass	.050	.036	.025	.029
17	Primary metals	.095	.002	.046	.001
18	Fabricated metals	.098	.060	.068	.025
19	Nonelectrical machinery	.029	.004	.009	.001
20	Electrical machinery	.033	.002	.003	.001
21	Motor vehicles	.041	0	.032	0
22	Other transportation equipment	.006	0	.001	.001
23	Instruments	.008	.004	.002	0
24	Miscellaneous	.010	.003	.003	0
25	Transportation	.099	.056	.050	.052
26	Communication	.034	.022	.016	.017
27	Utilities	.056	.024	.032	.025
28	Wholesale trade	.119	.080	.067	.054
29	Retail trade	.116	.088	.080	.076
30	Eating and drinking establishments	.052	.036	.030	.029
31	Finance	.039	.027	.018	.012
32	Insurance	.042	.029	.028	.010
33	Real estate	.096	.059	.036	.045
34	Lodging and amusements	.021	.013	.009	.008
35	Personal services	.021	.014	.014	.006
36	Business services	.117	.092	.087	.056
37	Health services	.047	.019	.035	.017
38	Other services	.072	.049	.042	.031
39	Household	.977	.700	.702	.592
Total		**3.843**	**2.567**	**2.540**	**2.183**

Table C2.6.-RIMS II **Multipliers--Maintenance and Repair, Residential (73)**

Industry	United States	Denver, Colorado	Detroit, Michigan	Wilmington, North Carolina
1 Agriculture	0.068	0.004	0.003	0.005
2 Forestry and fisheries	.003	0	0	.001
3 Coal mining	.005	.001	0	0
4 Petroleum and natural gas	.033	.008	0	0
5 Other mining	.007	.001	.001	.001
6 New construction	0	0	0	0
7 Maintenance and repair	1.030	1.016	1.015	1.011
8 Food and kindred products	.119	.047	.031	.009
9 Textiles	.032	0	.001	.007
10 Apparel	.027	.006	.003	.012
11 Paper	.036	.004	.003	.001
12 Printing	.032	.015	.008	.004
13 Chemicals	.183	.082	.083	.008
14 Rubber and leather products	.036	.007	.017	0
15 Lumber and furniture	.049	.016	.005	.005
16 Stone, clay, and glass	.031	.011	.010	.004
17 Primary metals	.062	.001	.022	0
18 Fabricated metals	.063	.029	.032	.001
19 Nonelectrical machinery	.067	.013	.016	.001
20 Electrical machinery	.059	.003	.004	.001
21 Motor vehicles	.040	0	.028	0
22 Other transportation equipment	.006	0	.001	.001
23 Instruments	.011	.002	.001	0
24 Miscellaneous	.019	.003	.004	0
25 Transportation	.101	.057	.051	.048
26 Communication	.037	.023	.017	.017
27 Utilities	.057	.025	.031	.021
28 Wholesale trade	.134	.092	.076	.060
29 Retail trade	.166	.135	.121	.121
30 Eating and drinking establishments	.054	.037	.030	.028
31 Finance	.041	.027	.018	.011
32 Insurance	.042	.029	.027	.009
33 Real estate	.102	.062	.037	.045
34 Lodging and amusements	.021	.013	.008	.007
35 Personal services	.021	.014	.013	.006
36 Business services	.068	.040	.036	.019
37 Health services	.047	.018	.032	.015
38 Other services	.067	.043	.035	.025
39 Household	.965	.661	.649	.531
Total	**3.942**	**2.545**	**2.470**	**2.036**

Table C2.7.-RIMS II Multipliers--Maintenance and Repair of Other Nonfarm Buildings (74)

Industry	United States	Denver, Colorado	Detroit, Michigan	Wilmington, North Carolina
1 Agriculture	0.073	0.005	0.003	0.005
2 Forestry and fisheries	.002	0	0	.001
3 Coal mining	.005	.001	0	0
4 Petroleum and natural gas	.026	.005	0	0
5 Other mining	.009	.001	.001	.001
6 New construction	0	0	0	0
7 Maintenance and repair	1.032	1.017	1.016	1.014
8 Food and kindred products	.128	.051	.034	.010
9 Textiles	.030	0	.001	.008
10 Apparel	.027	.004	.002	.014
11 Paper	.031	.003	.002	.001
12 Printing	.032	.015	.008	.004
13 Chemicals	.136	.042	.045	.008
14 Rubber and leather products	.036	.005	.016	0
15 Lumber and furniture	.039	.004	.002	.005
16 Stone, clay, and glass	.065	.014	.018	.010
17 Primary metals	.065	.001	.023	0
18 Fabricated metals	.061	.026	.028	.002
19 Nonelectrical machinery	.063	.011	.013	.001
20 Electrical machinery	.070	.006	.006	.001
21 Motor vehicles	.043	0	.031	0
22 Other transportation equipment	.006	0	.001	.001
23 Instruments	.011	.003	.001	0
24 Miscellaneous	.012	.003	.003	0
25 Transportation	.107	.059	.054	.054
26 Communication	.041	.027	.020	.021
27 Utilities	.060	.026	.032	.024
28 Wholesale trade	.128	.084	.070	.056
29 Retail trade	.145	.111	.100	.099
30 Eating and drinking establishments	.062	.044	.036	.036
31 Finance	.047	.032	.022	.014
32 Insurance	.046	.032	.030	.011
33 Real estate	.112	.070	.043	.056
34 Lodging and amusements	.023	.014	.009	.009
35 Personal services	.023	.015	.014	.006
36 Business services	.077	.048	.044	.025
37 Health services	.050	.019	.034	.017
38 Other services	.075	.049	.040	.030
39 Household	1.028	.702	.698	.590
Total	**4.025**	**2.548**	**2.502**	**2.137**

Table C2.8.-RIMS II Multipliers--Maintenance and Repair of Highways and Streets (87)

Industry	United States	Denver, Colorado	Detroit, Michigan	Wilmington, North Carolina
1 Agriculture	0.073	0.005	0.003	0.006
2 Forestry and fisheries	.002	0	0	.001
3 Coal mining	.005	.001	0	0
4 Petroleum and natural gas	.031	.007	0	0
5 Other mining	.066	.046	.018	.059
6 New construction	0	0	0	0
7 Maintenance and repair	1.032	1.019	1.017	1.015
8 Food and kindred products	.127	.055	.036	.011
9 Textiles	.029	0	.001	.009
10 Apparel	.027	.005	.002	.016
11 Paper	.027	.003	.002	.001
12 Printing	.030	.015	.008	.004
13 Chemicals	.166	.050	.064	.015
14 Rubber and leather products	.031	.005	.014	0
15 Lumber and furniture	.031	.003	.001	.004
16 Stone, clay, and glass	.039	.029	.018	.020
17 Primary metals	.045	.001	.020	0
18 Fabricated metals	.058	.035	.040	.002
19 Nonelectrical machinery	.021	.003	.005	.001
20 Electrical machinery	.023	.002	.001	.001
21 Motor vehicles	.042	0	.033	.001
22 Other transportation equipment	.006	0	.001	.001
23 Instruments	.006	.002	0	0
24 Miscellaneous	.012	.004	.004	0
25 Transportation	.126	.085	.078	.083
26 Communication	.037	.025	.019	.020
27 Utilities	.059	.029	.035	.029
28 Wholesale trade	.108	.073	.060	.048
29 Retail trade	.124	.098	.087	.086
30 Eating and drinking establishments	.057	.043	.035	.036
31 Finance	.044	.032	.021	.015
32 Insurance	.043	.031	.029	.011
33 Real estate	.107	.070	.042	.056
34 Lodging and amusements	.022	.015	.010	.009
35 Personal services	.022	.016	.016	.007
36 Business services	.076	.052	.047	.030
37 Health services	.050	.021	.038	.019
38 Other services	.072	.051	.041	.032
39 Household	1.040	.781	.769	.676
Total	**3.920**	**2.710**	**2.615**	**2.325**

Table C3.1.-Gross Output and Earnings Impacts of Denver LPW Expenditures by Industry and Construction Type

(Thousands of 1972 dollars)

Industry	Gross output impacts by construction type			Total impacts	
	Warehouses (49)	Sewers (62)	Parks (64)	Gross output	Earnings
1 Agriculture	1	15	1	17	4
2 Forestry and fisheries	0	0	0	0	0
3 Coal mining	0	2	0	2	1
4 Petroleum and natural gas mining	1	7	1	9	1
5 Other mining	2	34	2	38	9
6 New construction	213	2,359	132	2,704	868
7 Maintenance and repair	4	39	2	45	20
8 Food and kindred products	11	109	6	126	18
9 Textiles	0	1	0	1	0
10 Apparel	1	9	1	11	3
11 Paper	1	7	0	8	2
12 Printing and publishing	4	34	2	40	14
13 Chemicals	9	45	3	57	11
14 Rubber and leather	1	10	1	12	4
15 Lumber and furniture	2	7	1	10	3
16 Stone, clay, and glass	12	268	5	285	85
17 Primary metals	1	103	0	104	36
18 Fabricated metals	33	103	8	144	35
19 Nonelectrical machinery	2	105	1	108	37
20 Electrical machinery	1	11	0	12	5
21 Motor vehicles	0	0	0	0	0
22 Other transportation equipment	0	1	0	1	0
23 Instruments	1	11	0	12	4
24 Miscellaneous manufacturing	1	7	0	8	2
25 Transportation	16	149	7	172	70
26 Communication	6	55	3	64	20
27 Utilities	6	63	3	72	9
28 Wholesale trade	19	211	11	241	100
29 Retail trade	22	191	12	225	103
30 Eating and drinking establishments	9	88	5	102	35
31 Finance	7	66	4	77	24
32 Insurance	6	74	4	84	36
33 Real estate	15	144	8	167	8
34 Lodging and amusement	3	31	2	36	12
35 Personal services	3	32	2	37	18
36 Business services	24	185	12	221	93
37 Health services	4	41	3	48	18
38 Other services	10	107	6	123	51
39 Household	150	1,525	92	1,767	8
Total*	**451**	**4,724**	**248**	**5,423**	**1,767**

*Gross output totals exclude earnings impacts to avoid double counting; see equation 4.12.

Table C3.2.-Gross Output and Earnings Impacts of Detroit LPW Expenditures by Industry and Construction Type

(Thousands of 1972 dollars)

	Industry	Gross output impacts by construction type					Total impacts	
		Other buildings (55)	Streets and highways (64)	M & R residents (73)	M & R buildings (74)	M & R streets and highways (87)	Gross output	Earnings
1	Agriculture	18	8	1	4	4	35	7
2	Forestry and fisheries	0	0	0	0	0	0	0
3	Coal mining	0	0	0	0	0	0	0
4	Petroleum and natural gas	1	0	0	0	0	1	0
5	Other mining	13	34	0	1	21	69	21
6	New construction	5,218	2,462	0	0	0	7,680	2,611
7	Maintenance and repair	89	39	523	1,175	1,183	3,009	1,335
8	Food and kindred products	177	72	16	39	42	346	50
9	Textiles	3	1	1	2	1	8	2
10	Apparel	9	4	2	2	2	19	5
11	Paper	12	5	1	2	2	22	6
12	Printing	45	19	4	9	9	86	35
13	Chemicals	120	147	43	53	74	437	82
14	Rubber and leather products	87	24	9	19	16	155	40
15	Lumber and furniture	91	3	3	2	1	100	29
16	Stone, clay, and glass	208	184	5	20	21	438	130
17	Primary metals	356	111	11	26	24	528	140
18	Fabricated metals	533	172	17	33	46	801	251
19	Nonelectrical machinery	119	16	8	15	6	164	62
20	Electrical machinery	43	5	2	7	1	58	19
21	Motor vehicles	166	68	15	36	38	323	44
22	Other transportation equipment	7	3	1	2	2	15	6
23	Instruments	7	1	1	1	0	10	4
24	Miscellaneous	16	18	2	4	5	45	14
25	Transportation	307	178	26	62	91	664	302
26	Communication	106	39	9	23	22	199	64
27	Utilities	187	80	16	38	40	361	46
28	Wholesale trade	390	192	39	81	69	771	325
29	Retail trade	478	189	62	116	102	947	438
30	Eating and drinking establishments	184	69	15	42	41	351	121
31	Finance	113	42	9	25	25	214	67
32	Insurance	147	66	14	35	34	296	130
33	Real estate	229	85	19	50	48	431	22
34	Lodging and amusement	52	20	4	10	11	97	33
35	Personal services	78	32	7	17	18	151	73
36	Business services	741	172	19	51	54	1,037	456
37	Health services	184	75	17	40	44	360	137
38	Other services	204	91	18	47	48	408	156
39	Household	3,728	1,525	334	807	894	7,288	25
Total*		**10,737**	**4,726**	**939**	**2,089**	**2,145**	**20,636**	**7,288**

*Gross output totals exclude earnings impacts to avoid double counting; see equation 4.12.

Table C3.3.-Gross Output and Earnings Impacts of Wilmington LPW Expenditures by Industry and Construction Type

(Thousands of 1972 dollars)

Industry	Gross output impacts by construction type	Total impacts	
	M & R streets and highways (87)	Gross output	Earnings
1 Agriculture	4	4	2
2 Forestry and fisheries	1	1	0
3 Coal mining	0	0	0
4 Petroleum and natural gas	0	0	0
5 Other mining	42	42	13
6 New construction	0	0	0
7 Maintenance and repair	726	726	340
8 Food and kindred products	8	8	2
9 Textiles	7	7	2
10 Apparel	11	11	3
11 Paper	1	1	0
12 Printing	3	3	2
13 Chemicals	11	11	2
14 Rubber and leather products	0	0	0
15 Lumber and furniture	3	3	1
16 Stone, clay, and glass	14	14	3
17 Primary metals	0	0	0
18 Fabricated metals	2	2	0
19 Nonelectrical machinery	0	0	0
20 Electrical machinery	0	0	0
21 Motor vehicles	0	0	0
22 Other transportation equipment	1	1	0
23 Instruments	0	0	0
24 Miscellaneous	0	0	0
25 Transportation	59	59	21
26 Communication	14	14	5
27 Utilities	21	21	3
28 Wholesale trade	34	34	14
29 Retail trade	62	62	27
30 Eating and drinking establishments	26	26	8
31 Finance	11	11	3
32 Insurance	8	8	3
33 Real estate	40	40	2
34 Lodging and amusement	7	7	2
35 Personal services	5	5	2
36 Business services	21	21	9
37 Health services	14	14	4
38 Other services	23	23	8
39 Household	483	483	2
Total*	**696**	**696**	**483**

*Gross output total excludes earnings impacts to avoid double counting; see equation 4.12.

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